THE *Petroleum* Engineer — Management Edition

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XUM

A Basic Investment

The petroleum industry is quietly doing a magnificent job in aiding worthy young men and women to acquire an education. Scholarships run into the thousands. Many companies help to educate sons and daughters of employees. Almost any person of high scholastic standing can obtain financial aid for postgraduate work.

This is in addition to educational programs for employees either conducted by the company or sponsored by the company and given at a university.

It is not only the large established companies who help with education. Many individual oil and gas operators have done more than their share. One oil man we know is helping 25 university undergraduates.

A number of industry associations conduct short courses in colleges and universities and others finance research projects, which benefit both the school and industry. Several individual Desk and Derrick Clubs sponsor scholarships.

Occasionally corporations have been obstructed by stockholders who see educational funds as withheld dividends but test court cases have approved the practice of business and industry-sponsored educational programs. There is no question that funds for education, if wisely spent, are as surely an investment as funds for plant and equipment.

The rising demand for expanding faculties and schools to accommodate a fast growing population with a desire and vital need for better education must be met more and more by individual and industry backing. Otherwise, states and local governments will have to call upon the federal government for more help. The federal government already spends $2.5 billion a year on educational programs and there is constant pressure from misnamed "liberal" groups for greater federal aid to education.

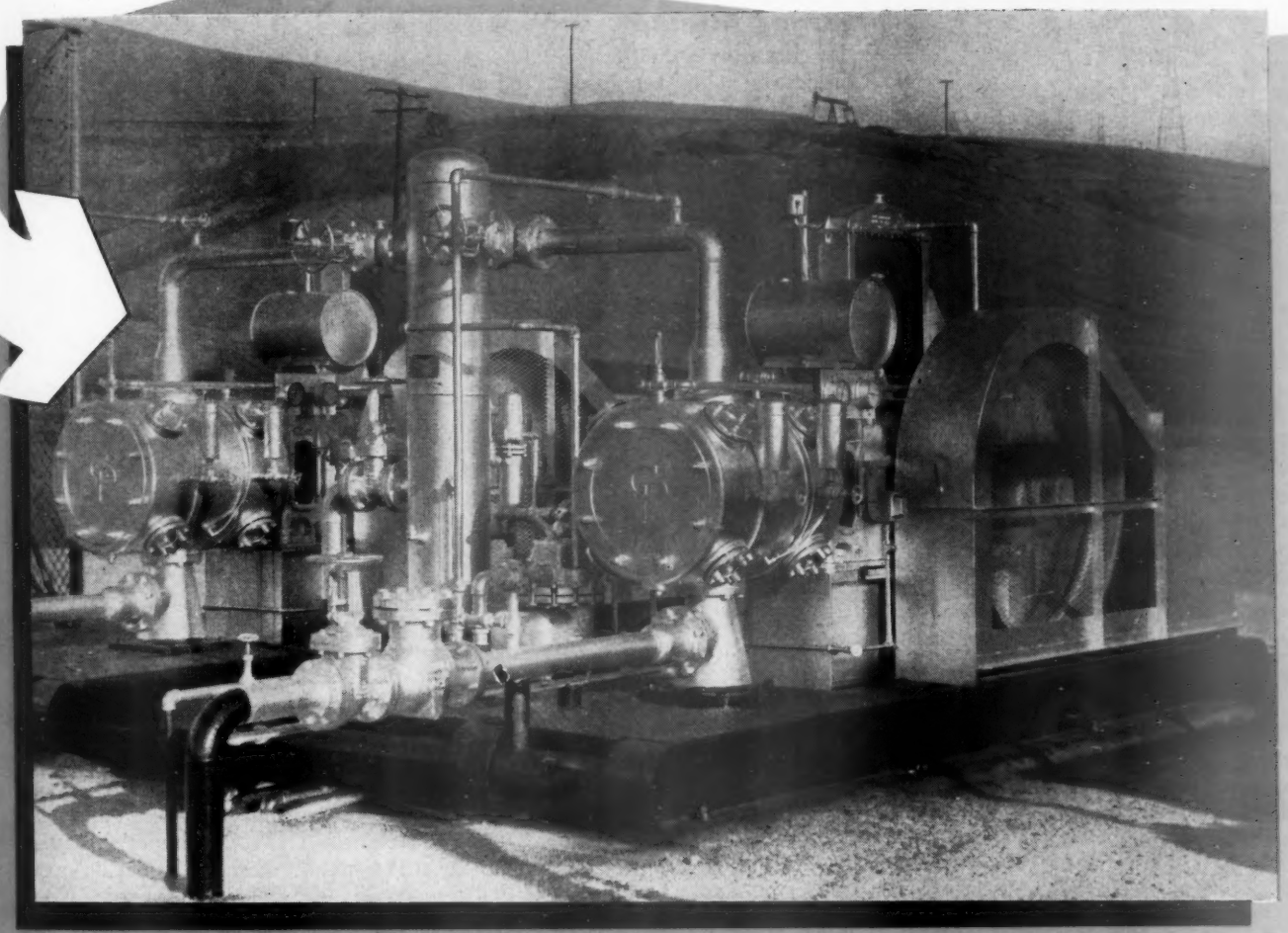
Traditionally, the people of the U. S. have resisted national education. The Socialist and Communist theory of educating the young for the state and loosening the ties at home has not found favor here and any steps in this direction, no matter how small, have brought strong opposition from conservative forces.

But the pressure is mounting with growing requirements; only the firm backing of industry and business can check federal financing and, with it, federal control of education.

The petroleum industry must continue to lead the way in this vitally important course. An investment in education is a basic investment in trained people with respect for our private capitalist economic system.

Ernestine Adams.

These "Oilwell" Compressor Units are SAVING Storage Tank Vapors



WHAT HAPPENS to the vapors which rise from the oil that is stored temporarily in field tank farms?

The engineers of Shell Oil Company knew that the value of the vapors lost from light oil storage tanks would repay the cost of a vacuum system.

So they worked out a hook-up on one of their field tank farms near Brea, California, where a gas trap is installed, in which the two 75 hp "Oilwell" Compressor Units (shown above) would draw off the tank vapors. Both units are skid mounted side by side and take suction on a common line through the scrubber.

From 10" to 15" vacuum is being pulled and gases are now being recovered at the rate of 400,000 to 700,000 cubic feet per day.

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UNITED STATES STEEL

1954

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HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Iran Agreement Reached

Howard W. Page, the chairman of the representatives of eight international oil companies who have negotiated an agreement with Iran to resume production of its oil, says Iranian parliament will ratify the agreement. Page said the Iranian agreement is merely a memorandum and that the companies expect final agreement and ratification by Iranian government by October 1.

★ ★ ★

Union Leaders Sentenced

Three construction trades union leaders have been sentenced to heavy prison terms in St. Louis, Missouri, for the shakedown of an Oklahoma pipe line contractor. Three of the terms were for 12 years and one for 10 years. In addition to the sentences the four were placed on 5 years probation at the end of their sentences.

★ ★ ★

FPC Denies Gas Rate Hike

Michigan-Wisconsin Pipe Line has been denied a gas rate increase by the FPC. Increase was based on the "Escalator" clause in contracts with Phillips Petroleum Company, which the commission says it must approve before rates are increased.

★ ★ ★

Profits Up With 1953

Profits from American industry and trade are keeping pace with 1953 according to the reports of 416 corporations. Combined net profits of the 416 amounted to $3,335,328.254 as compared to $3,268,213,308 in the first half of 1953. Oil companies are ahead of last year by 7 per cent but current production, sales, and price problems are tending to reduce that gain.

★ ★ ★

Crude Prices to Hold

E. R. Peterson, Standard of California vice president, in speaking before the Los Angeles, California, Society for Security Analysts declared his belief that crude oil prices will hold at present levels and that U. S. petroleum inventory situation will be corrected "within a reasonable time." Peterson predicted that gasoline demand would register a 2.9 per cent gain throughout the nation this year.

★ ★ ★

Merger Attempts Dropped

Attempts by American Republic's Corporation and Tennessee Production Company to merge have been abandoned. A proposal is said to be forthcoming for a merger of Tennessee Production with Tennessee Gas Transmission Company which owns about 49 per cent of Tennessee Production's common stock. Tennessee Gas has 18 per cent of American Republic's stock.

★ ★ ★

FPC Modifies Order

Independent producers of natural gas whose interestate sales will be less than one billion cubic feet a year have been authorized by the FPC to use a simplified application form in requesting commission certificates of approval. This procedure amends order No. 174 which stated that only those producers in operation on June 7 could use the simplified form.

★ ★ ★

Production Record Set

A world's crude oil production record was set in February according to a report by the Bureau of Mines. World production was 13,392,000 bbl daily. Middle East output hit a new high with an average of 2,587,000 bbl daily.

★ ★ ★

Tide Water Buys Company

Tide Water Associated Oil Company has purchased Star and Crescent Oil Company, San Diego, California, distributors for Tide Water products for the past 30 years. Tide Water acquires four distribution plants, a marine service station and a chain of service stations in California.

★ ★ ★

FPC Fund Request Vetoed

FPC's request for an additional $300,000 appropriation to cover extra costs due to regulating independent producers and gatherers of natural gas has been turned down by the Senate.

Union Oil Plans Building

Union Oil Company of California has announced plans to build a headquarters building in Los Angeles, California. No date for construction has yet been set.

★ ★ ★

Oil Tanker Pact Hurts U. S.

Representative Celler (D., New York) has declared that the tanker monopoly created by Aristotle Onassis with Saudi Arabia will cost American taxpayers $16,000,000 a year. Celler said the shipping rate set by Onassis would result in countries having to pay a higher price for its oil shipments, which would cause them to ask for more loans and grants from the U. S.

★ ★ ★

Land Lease Bill Signed

A bill modernizing the existing leasing laws has been signed by President Eisenhower. Another bill, providing for liberalization of acreage limitations and leasing terms, awaits action.

★ ★ ★

Oil Import Rise Predicted

Reports by IPAA to the Texas railroad commission on the imports of foreign oil shows the imports for the first 6 months of this year has dropped to 1,051,000 bbl daily average, a decrease of 26,000 bbl from 1953. Estimates of imports for the last half of the year predicate a rise of 107,000 bbl daily for total of 1,130,000 bbl.

★ ★ ★

Tax Bill Hailed

Russell Brown, counsel for the IPAA, has voiced approval of the inclusion in the new general tax revision bill of specific language giving an oil operator the option of expensing his intangible drilling costs. Another important change in the bill, Brown said, was the revision of a section pertaining to net operation loss deductions.

★ ★ ★

U. K. Consumption Up

Figures released on United Kingdom consumption of oil products in 1953 shows an increase of 8½ per cent over 1952 consumption.

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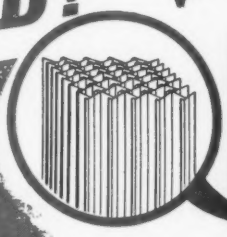
GUARANTEED!

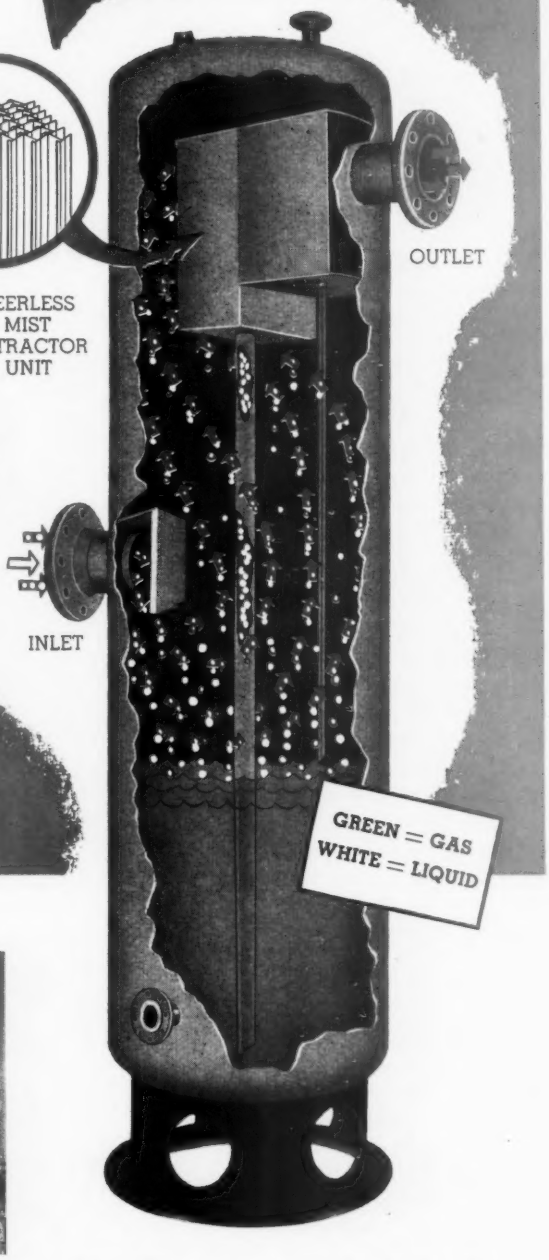
PLUS

GREATER EFFICIENCY

MAXIMUM SEPARATION

MINIMUM PRESSURE DROP

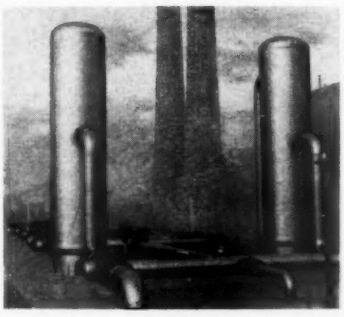




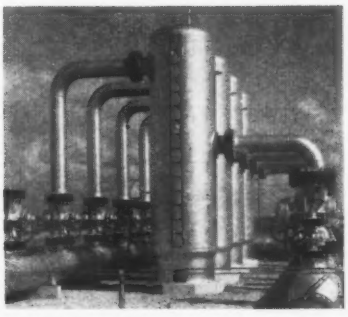
The Peerless Vertical Gas Scrubber, proved by many years of continued use throughout the oil and gas industry, is the result of careful engineering, design, manufacturing and much field experience.

These units have equally high efficiency at low or high gas flows. This efficiency is maintained whether a fine entrainment or slugging problem exists.

Through the use of the famous Peerless Mist Extractor Unit, now serving so efficiently in scrubbers, fractionators, absorption towers, refineries, and gasoline plants throughout the world, Peerless can build their scrubbers smaller than most scrubbers of other makes and... PEERLESS CAN GUARANTEE THE PERFORMANCE OF THESE SCRUBBERS! THEY ARE GUARANTEED TO REDUCE ENTRAINMENT LOSS TO LESS THAN 1/10 GALLON PER MILLION STANDARD CUBIC FEET OF GAS!



Two Peerless 48 x 19 Scrubbers, each handling 50 million CFPD at 250 PSI on inlet of a power plant in South Texas.



FOUR Peerless 60" x 19" Scrubbers handling a total of 132,000,000 CFPD at 600 PSIG, working pressure. Located at new pipeline compressor station.

Shown above is a cutaway of a Peerless Vertical Scrubber. This illustration indicates the path followed by the gas stream as it passes through the scrubber.

Peerless Precision Engineered Scrubbers available in vertical or horizontal sizes or can be built to your requirements... FOR ANY GAS FLOW... FOR ANY WORKING PRESSURE.

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Gas Ruling Restudy Asked

Ohio Oil Company and Magnolia Petroleum Company have asked the FPC to restudy its July 16 order and to hold up any action until the study is completed.

Humble Oil and Refining Company has asked the commission to delay beginning of controls until June 1, 1955. Commission has set October 1 as the date.

Texas Independent Producers and Royalty Owners Association has asked for a hearing before the commission on November 4, a date set for a hearing on escalator clauses.

Continental Oil Company has petitioned the FPC to repeal its order No. 174-A. Company contends the order is "invalid, unlawful, and improper" because it was issued without notice and attempts to freeze gas prices retroactively.

★ ★ ★

Oil Investigation Urged

Representative Steed (D-Oklahoma) has disclosed the fact that some members of Congress from oil-producing states are considering asking a Congressional investigation of reasons for present over-supplies of petroleum products. Steed said that he believed a congressional committee inquiry would be probably the best way to get the facts.

★ ★ ★

Change Planned for B of M

A Bureau of Mines reorganization plan has been recommended by a 5-man survey team. Plan would take the government out of the helium-producing business and reduce the number of regions from 9 to 4. U. S. has been producing helium since 1922.

★ ★ ★

Oil Import Study Pledged

ODM director Flemming has pledged oil-state congressmen that President Eisenhower's national fuels policy committee not only will consider the oil imports problem but will receive presentations from independent producers as to their views.

★ ★ ★

Pipe Line Motion Refused

A motion by American Louisiana Pipe Line Company and its two affiliates for the FPC to rule separately on its applications to build a $159,000,000 pipe line system and the applications of its proposed suppliers, has been turned down by the FPC. In an August 2 ruling FPC held that in the absence of applications from proposed suppliers no favorable action could be taken on the 3 companies applications.

★ ★ ★

Use of Name Upheld

Exclusive use of the name "Standard" by the Standard Oil Company (Indiana) has been upheld again by a federal court; this time for use in North Dakota. Ruling makes North Dakota the fifteenth state in which the company has the exclusive use to the name of "Standard."

★ ★ ★

Dividend Payments Rise

Dividend payments of a majority of corporations are 7.5 per cent higher than a year ago. Some 7,000,000 corporate stock owners have received the increase.

★ ★ ★

U. S.-Mexico Hold Talks

Negotiators have been reported to be urging stepped-up talks between U. S. and Mexico on a proposal to export natural gas north of the Rio Grande. Proposal foresees export of millions of cubic feet of gas daily.

Oil Companies Merge

Standard of Indiana has made effective its merger with its eastern subsidiary, Pan American Petroleum and Transport Company. Action on the merger had been postponed until the new federal tax legislation had been passed.

★ ★ ★

Gulf Coast Prices Up

Gulf Coast refiners predict that fuel oil used for home heating may be raised again. Cargo prices on No. 2 fuel rose a half cent since July 28 and is now quoted at 8¼ cents a gallon.

Bulk cargo prices for 3 grades of regular gasoline has also risen on the Gulf Coast. A ¼-cent rise has restored the price of 84-octane to 10 cents a gallon. Eighty-seven octane has increased ¼ cent to 10½ cents a gallon and 83-octane had a raise of ⅛ cent to 9⅞ cents.

★ ★ ★

Auto Merger Approved

A merger of the Studebaker Corporation with the Packard Motor Car Company has been approved by Studebaker and Packard stockholders. New company will be called Studebaker-Packard Corporation. Merger strengthens two of the smaller automobile companies and should result in increased competition in selling more cars.

A Quarter Century of Progress . . .

in petroleum engineering will be featured in The Petroleum Engineer's October Silver Anniversary Issue.

Look into the future of the petroleum industry with:

What's Ahead?

Will atomic energy affect petroleum demand?

Will sonic energy drill wells?

Will jet turbines change refining programs?

Be sure to read far-reaching forecasts for the petroleum industry . . . coming your way in The Petroleum Engineer's October — 25th Anniversary Issue.

Ask a Mercantile Man

...about Pipelines to Profit

Whether your plans call for constructing a pipeline to take natural gas to market, or drilling half a dozen new wells, adequate financing comes first. With their extensive experience and technical knowledge, the men in our Oil and Gas Department are in a position to give you sound, constructive suggestions. You'll find they understand your problems and speak your language. A workable plan of financing, related to your tax requirements, is fundamental. So come in and get acquainted with a Mercantile man when you have a financing problem.

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DALLAS, TEXAS

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

PETROLIC PERSONALITIES

DICK SNEDDON

TEXAS TYCOONS PROMOTE GATHERING

At the invitation of two noted Texans, to wit, Ed Trout, the Lufkin vice president from Lufkin, and Alvin "Dutch" Zwerneman, the substantial Houstonian, we hied to the Jonathan Club in Los Angeles one recent evening and in no time at all found ourselves in the middle of such a group of celebrities as hasn't been seen since the opening of "Gone With The Wind."

Among them we spotted Bill Kinder, the eminent Emsconian from Dallas, who had just returned from a Honolulu vacation with his old Coalinga school chum, Ed Webb, Continental Oil Company vice president from Houston; Tom Wallace, the Western Gulf top hand, and Jay Wharton, one of his more consequential aides, with which pair of sharpies we later played tick-tack-toe and almost lost our shirt — the one with the Hollywood cuffs, too; Frank Lortscher, the Flying Dutchman from Signal Oil and Gas Company, who has more aviating miles to his credit than a bald-headed eagle; his right arm, Kenny Dale, the PPP receptionist; Walt Greenfield, Signal's vice president in charge of production and a song leader of note; Paul Andrews, the well known engineer from the same institution with some advice no how to choose a vocation for one's child; Charley Perkins, Union's manager of purchases, and Milan Arthur, a high ranking engineer for the 7600, both of whom tossed out bits of petrolic folklore for the edification of the assembled warriors; Bill Lyte, Douglas Oil Company veep whose story of Higgins of San Francisco was one of the best we've heard in a long time; and Ollie Branyon, buyer of tubing, casing, derricks, valves, etc., for the Flying Horse, and a stout lad to have in an impromptu quartet.

ABOUT THE FESTIVE BOARD

Then there were Martin Newell, the Tidewater philosopher, with Tom Weaver, the southern division superintendent for same; Ray Zell, the fast rising Union Oiler and a mighty lucid platform discourser; Hal Marsh, GP's production manager, once a prolific writer on engineering topics and still one of the best informed in the business; John Hills, perennially young engineer and fly fisherman, and Don Dawkins, estimable chief materials engineer, both also from the Pegasusian institution; Emery Squires, the genial Richfield purchasing chief, not too long enthroned but looking quite comfortable in his royal robes; Fred Currie, the Copperweld mogul, buddy of Baron Long, and a popular Nineteener; Monte Lindmoe, the golden-voiced executive vice president of Southwest Welding; Sam Patterson, the pleasant mannered Bankliner and low handicap divot lofter; John Augsburger, the Tryad Corporation chap to whom we recently gave credit for an outstanding golf drive that was made by his son; Bill Cochems, the Standard Oil production potentate from Murphy Coyote; Ed Masters, Dutch Schmieder, Bert Eastin, and Bob Kettenburg, a quartet of high quality TCP people; Charlie Beyrle, another Chevronite from out Coyote way, who swings a mean niblick; Clint Eddleman and R. A. Holman, a pair of well regarded Ameradans; Marshall Lewis, the purchasing caliph, and Johnny Stevens, assistant to H. L. Briggs, both from CCMO; Harry Campbell, the very friendly young president of Franco Western Oil Company, up Bakerstown way; and from the Texaco came Harold Puls, division manager of production, one of our better citizens, and H. E. "Woody" Woodruff, his next in command.

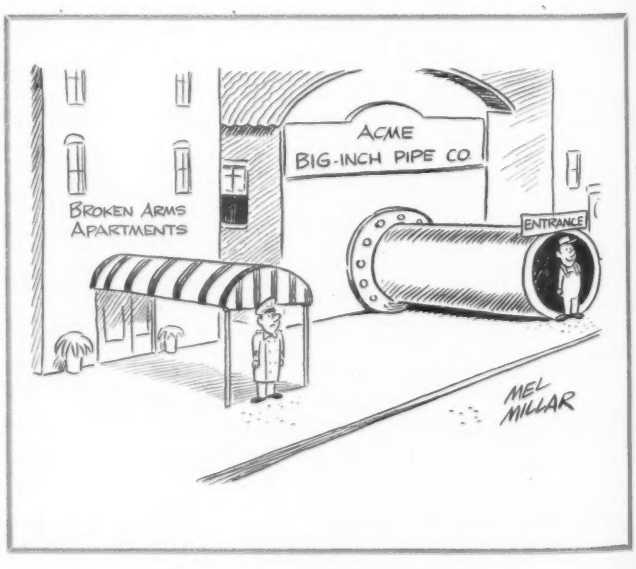
INTRODUCING MR. HIGGINS

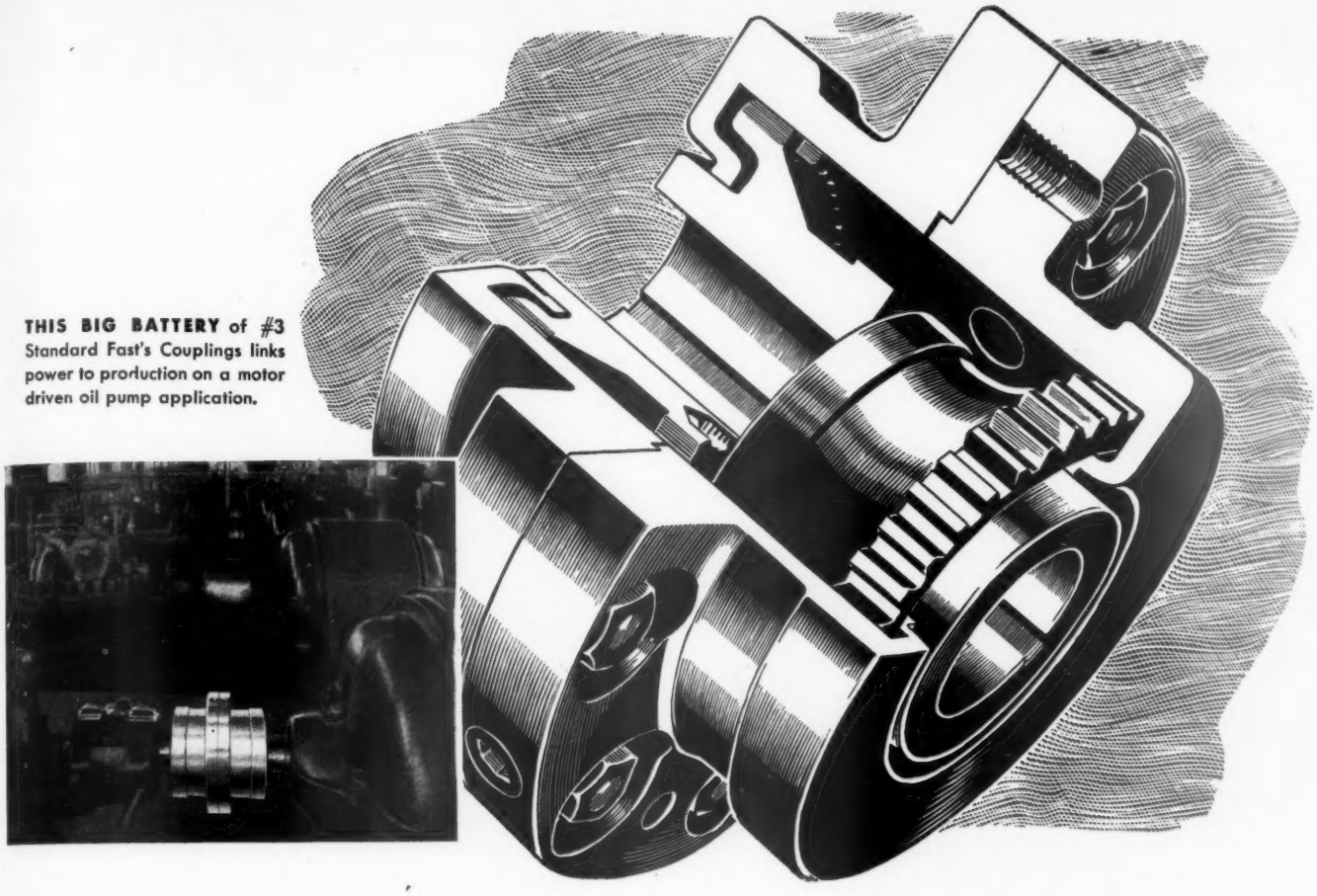
Also present were Doug Kingman, GP's manager of joint ventures, consequently familiar with the location of the joints; three Bakersfield delegates who drove down together, namely, Jack Sheppard, Humble's Valley superintendent; Bill Nance, a highly reputable Shell chap; and Carl Frazer, a well regarded member of the Lufkin family; three top level California Humbletonians — John Bell, assistant area manager, Sam Barclay, petroleum engineer, and Hugh Barton, geologist; Martin D'Errico and Bill Corey, a pair of popular people from Lacy Oil Tool Company; Frank Hardesty and Bob Gray, the Long Beach Oil Development lead men; John McLeod and Ed Pellegrin, the Macconian upper crust, John reciting one of his delightsome Gaelic idylls; Gene Davis, the former Alaskan, now with Monterey Oil Company; Jim McNeill, the rising consultant, and one of the best; Al Case, the oilfield transportation genius with the mobile telephone system; Ted Getzler, expediter on that Turkish refinery for Ralph M. Parsons; Bob Pollard, assistant exploitation manager, Windy Payne, engineer, Cec Martin and Bill Kreiger, purchasing hotshots, all from Richfield Corporation; Harold Hassell, Richfield's Ojai superintendent; A. M. "K" Kuehmsted and Jack Slough of Santa Fe Tank Company; and another pair of consequential Shell folk, Paul Lehr, Los Angeles Basin production manager, and D. K. Stewart, district superintendent.

AND SO TO BED

Others noted were Hal Acres, chief engineer for Sunray; Standard oilers Art Wilson and Jack Bagnall from Murphy Coyote; Pike Eimer, the purchasing biggie from Bagdad by the Bay, and Tich Tichenor and Fred Eberly from the Los Angeles purchasing department; Judge Saatjian, the affable Texaco chap, with Howard Stone, Bakersfield superintendent, and engineer, Bob Corey; Lee Osborne and Charlie Keeble from Union Pacific; three more representatives of Western Gulf, namely, Harry Brigham, Les Smith, and Bill Walker; Bill Westergard, the Hancock purchasing agent, a noted Nineteener; and that's about as many as we can remember.

We do remember, however, that it was a most enjoyable affair from start to finish.





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When you specify Fast's Couplings, you get the benefit of Koppers *free engineering service* . . . your assurance of the right coupling for any job and the right solutions to tough coupling problems.

FOR EXAMPLE: "Get the drawings and send them down to Koppers" is the standard answer in one plant whenever a tough coupling application arises!

FOR EXAMPLE: After studying a list of spares for stand-by units made up by one customer, a Koppers sales engineer eliminated duplications . . . resulting in a smaller order for him but a *much smaller inventory* for the customer!

Add the *rugged construction* of Fast's Couplings . . . with their original design maintained without basic change or sacrifice in size or materials. Add their lowest cost per year . . . their life expectancy guarantee. *Fast's usually outlast the equipment they connect.* Result: it will pay you to write today for full details on how Fast's Couplings and Koppers Engineering Service can help you get uninterrupted power transmission! Send for free catalog to: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 269 Scott Street, Baltimore 3, Md.

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Petroleum Profile

PROBABLY the most amazing job of the several that James E. Pew has held was official weatherman in one district for the Cuban Government Weather Bureau, while busily engaged as a manganese mining engineer for The Sun Oil Company, also in Cuba.

The most irritating job he ever lived through could have been that of railroad engineer on the narrow-gauge railroad that he built from this same Cuban mine to sea level, where on its first trip the gasoline locomotive jumped the track 14 times.

Doubtless the most thrilling experience in his youngster days was being mistaken for the popular "Buster Brown" comic strip character, when he arrived in a suit of that design at Waynesburg, Pennsylvania, the same day an impersonator of Buster Brown was to appear there in person.

No career among oil or gas men has been more varied or more full of the unusual than has that of Jimmie Pew, vice-president of Sun Oil's natural gas and natural gasoline department, and president of the recently incorporated National Council for LP-Gas Promotion, a joint enterprise of LPGA, NGAA, and GAMA.

Jim started his oil-and-gas career as a soap-bubble-swabber in western Pennsylvania when he was handed a bucket full of soapy water and a swab or cloth wiper and directed to follow a gas pipe line, swab each joint with the soapsuds, and watch with eagle eye for any telltale bubbles indicating leaks. Odorizing gas with mercaptans or skunk essence or what-ever had not been thought of then. Jim was born with more than the average amount of oil or gas in his blood stream; son of John G. Pew, twin brother to J. Edgar Pew, the latter head of Sun Oil until recently. John G. was president of Sun Shipbuilding and Dry Dock Company until 1953.

Jim went to public school in Pittsburgh; he was a military academy student for a time, then plunged into Cornell, baseball and all. He also studied chemical engineering but after two years of the "cloistered halls of ivy" he had enough. He had worked summers as a soap bubbler in Pennsylvania, rock hound in Oklahoma, and as a clerk in a gasoline plant office in West Virginia; and now Sun Development Company sent him to Cuba to help build the mine at Bayamo.

Jimmie Pew

JAMES E. PEW, *Director, Sun Oil Company*

His mine building experience taught him, he didn't know enough engineering; so he went back to school, this time to M.I.T., Cambridge, Massachusetts. He married Marjorie Harvey in 1923, went to Bradford, Pennsylvania and built the first (horizontal absorber) charcoal absorption plant in the world, it is believed; stayed a year, got the plant to operating and left.

Jim went to Hope Construction and Refining Company, studied efficiency of gasoline plants, hunted special equipment for using propane, and laid some of the real pioneer foundations for the liquefied petroleum gas industry. Went to Hope Natural Gas Company for a brief sojourn, and finally wound up as supervisor for building seven charcoal gasoline absorption plants for Virginian Gasoline and Oil Company, a Charleston, West Virginia company. The company bought more plants and made Jim superintendent of the lot. He spent 16 years with Virginian, taking time out long enough to help build the first all-welded gas pipe line. It seems he was in on quite a number of firsts in the gas-gasoline industry.

Before World War II he was called to Washington to join the Office of Petroleum Coordinator, predecessor of wartime PAW and our post war PAD. Jim came out of that "hassle" as director of the natural gas and gasoline division. He had been responsible largely for doubling natural gasoline's production of fractions going into chemicals, synthetic rubber, aviation and motor fuels. That little job was responsible in great measure for the Hanlon Award by the NGAA in 1945, a signal honor reserved normally for research and/or development chemists or engineers.

Jim came back to Sun after the war and took over the reins of the new natural gas and natural gasoline divisions. He became a Sun director in 1950, and fell immediately into his old habits — building a lot of units and plants to conserve gas and use it more efficiently. There are those who say he won't stay long where there's nothing to be built or rebuilt.

Pew quit playing baseball (he was a catcher in prep school and college) and started fly fishing, whipping the mountain streams around West Virginia. He got too mixed up with official Washington to fish, bought a cruiser, Esperance (Hope in Spanish), and toured Potomac and Anacostia rivers. He now has a 36-footer, Esperance II, with which he cuts the waves of Chesapeake Bay. With two married daughters and three grandsons his family interests are broad and enduring.

In the face of all these experiences it may or may not be unusual that to Jim Pew "a bucket of suds" means not a malt beverage but a primitive gas leak detector!

Meetings

Sept. 7-8—**Association of Desk and Derrick Clubs of North America,** annual convention, Banff Springs Hotel, Banff, Alberta, Canada.

Sept. 8-10—**Oil Industry Information Committee,** Chicago, Illinois.

Sept. 8-10—**Pacific Coast Gas Association,** annual, Vancouver Hotel, Vancouver, B. C.

Sept. 9-11—**Interstate Oil Compact Commission,** Fontenelle Hotel, Omaha, Nebraska.

Sept. 12-16—**American Institute of Chemical Engineers,** Colorado Hotel, Glenwood Springs, Colorado.

Sept. 12-17—**American Chemical Society,** New York, New York.

Sept. 13-14—**Independent Natural Gas Association of America,** annual, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 13-14—**Packaging Institute,** petroleum packaging committee, Philadelphia, Pennsylvania.

Sept. 13-24—**Instrument Society of America,** International Instrument Congress and Exposition and National Instrument Conference and Exhibit, Philadelphia, Pennsylvania.

Sept. 15-16—**American Gas Association,** annual accident prevention convention, Bond Hotel, Hartford, Connecticut.

Sept. 15-17—**National Petroleum Association,** annual, Traymore Hotel, Atlantic City, New Jersey.

Sept. 15-29—**International Union of Geodesy and Geophysics,** general assembly, Rome, Italy.

Sept. 16-17—**Mid-Continent Oil and Gas Association,** Louisiana-Arkansas Division, annual, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 17—**Natural Gasoline Association of America,** Oklahoma regional, Skirvin Hotel, Oklahoma City, Oklahoma.

Sept. 23-24—**Western Petroleum Refiners Association,** regional, Henning Hotel, Casper, Wyoming.

Sept. 23-24—**National Industrial Conference Board,** Waldorf-Astoria Hotel, New York, New York.

Sept. 24—**Oklahoma Utilities Association,** gas division, Biltmore Hotel, Oklahoma City.

Sept. 27-28—**Independent Oil Compounders Association,** annual, Hotel Sheraton, Chicago, Illinois.

Sept. 27-28—**Symposium on Methods for Testing Liquefied Petroleum Gases,** Statler Hotel, St. Louis, Missouri.

Sept. 27-29—**American Institute of Electrical Engineers,** electrical conference for petroleum industry, Mayo Hotel, Tulsa, Oklahoma.

NOMADS TO MEET

New York, N. Y., Chapter, First Monday of the Month, Biltmore Hotel, New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First or Second Monday of the Month. Secretary, Glen Tableman.

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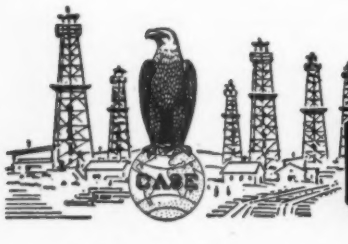

CASE

Sept. 27-30—**American Society of Mechanical Engineers,** Petroleum Division, annual, Statler Hotel, Los Angeles, California.

Sept. 28-29—**Texas Mid-Continent Oil and Gas Association,** Baker Hotel, Dallas, Texas.

Sept. 28-29—**American Petroleum Institute,** executive committee of board of directors, The Greenbrier, White Sulphur Springs, West Virginia.

Oct. 2—**Southern Gas Association,** right-of-way conference, Peabody Hotel, Memphis, Tennessee.

Oct. 3-7—**American Society for Testing Materials,** committee on petroleum products and lubricants, Sheraton Park Hotel, Washington, D. C.

Oct. 4-6—**Petroleum Electric Power Association,** annual, Jung Hotel, New Orleans, Louisiana.

Oct. 4-6—**Texas Mid-Continent Oil and Gas Association,** annual, Plaza Hotel, San Antonio, Texas.

Oct. 6-8—**Technical Conference on Petroleum Production,** annual, Mineral Industries Building, Pennsylvania State College, State College, Pennsylvania.

Oct. 7-8—**American Institute of Mining and Metallurgical Engineers,** Pacific Petroleum Chapter, Fall meeting, Biltmore Hotel, Los Angeles, California.

Oct. 7-8—**California Natural Gasoline Association,** annual, Ambassador Hotel, Los Angeles, California.

Oct. 11-13—**American Association of Oil Well Drilling Contractors,** annual, Biltmore Hotel, Los Angeles, California.

Oct. 11-14—**American Gas Association,** annual, Atlantic City, New Jersey, hotel to be named.

Oct. 12-15—**National Chemical Exposition,** annual, Chicago Coliseum, Chicago, Illinois.

Oct. 13—**American Institute of Chemical Engineers,** New York section, Symposium, Hotel Statler, New York, New York.

Oct. 14-17—**Permian Basin Oil Show,** Odessa, Texas.

Oct. 17-20—**American Institute of Mining and Metallurgical Engineers,** petroleum division, Fall meeting, Plaza Hotel, San Antonio, Texas.

Oct. 18-20—**American Institute of Mining and Metallurgical Engineers,** Petroleum Branch fall meeting, Plaza Hotel, San Antonio, Texas.

Oct. 18-22—**National Safety Congress and Exposition,** annual, Conrad Hilton, Morrison, Congress, LaSalle Hotels, Chicago, Illinois.

Oct. 21-22—**Western Petroleum Refiners Association,** regional, Garrett Hotel, El Dorado, Arkansas.

Oct. 24-26—**Independent Petroleum Association of America,** annual, Mayo Hotel, Tulsa, Oklahoma.

Oct. 25-27—**National Lubricating Grease Institute,** annual, Mark Hopkins Hotel, San Francisco, California.

Oct. 25-29—**American Institute of Electrical Engineers** (tentative date), Fall general meeting, Chicago, Illinois.

Oct. 26-27—**Society of Automotive Engineers,** national diesel engine meeting, Statler Hotel, Cleveland, Ohio.

Oct. 29—**Natural Gasoline Association of America,** Southern regional, Blackstone Hotel, Tyler, Texas.

Nov. 1-3—**Geological Society of America,** annual, Statler Hotel, Los Angeles, California.

Nov. 1-5—**American Society for Metals,** national, Palmer House, Chicago, Illinois.

Nov. 3-5—**Gulf Coast Association of Geological Societies,** annual, Rice Hotel, Houston, Texas.

Nov. 4-5—**Society of Automotive Engineers,** national fuels and lubricants meeting, Mayo Hotel, Tulsa, Oklahoma.

Nov. 8-11—**American Petroleum Institute,** annual, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 10—**American Petroleum Institute,** meeting executive committee of board of directors, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 15-17—**American Petroleum Credit Association,** annual, Muehlebach Hotel, Kansas City, Missouri.

Nov. 15-17—**American Standards Association,** annual, Roosevelt Hotel, New York, New York.

Nov. 15-17—**National Conference on Standards,** annual, Roosevelt Hotel, New York, New York.

Nov. 17-18—**American Institute of Mechanical Engineers,** North Texas section, and **North Texas Oil and Gas Association,** production committee, symposium on secondary recovery, Wichita Falls, Texas.

Nov. 18—**National Industrial Conference Board,** Conrad Hilton Hotel, Chicago, Illinois.

Nov. 18-19—**Society of Exploration Geophysicists,** Midwestern division, annual, Adolphus Hotel, Dallas, Texas.

Nov. 28-Dec. 3—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Nov. 30-Dec. 2—**Electronic Computer Clinic and International Automation Exposition,** 244th Regiment Armory, 14th St. between 6th and 7th Avenue, New York, New York. Address inquiries to Electronic Computer Clinic, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania.

Dec. 2-4—**Interstate Oil Compact Commission,** Winter meeting, Drake Hotel, Chicago, Illinois.

Dec. 2-7—**National Exposition of Power and Mechanical Engineering,** Commercial Museum, Philadelphia, Pennsylvania.

Dec. 3—**Natural Gasoline Association of America,** Panhandle Plains regional, Herring Hotel, Amarillo, Texas.

Dec. 8-10—**Oil Industry Information Committee,** Waldorf-Astoria Hotel, New York.

Dec. 12-15—**American Institute of Chemical Engineers,** annual, Statler Hotel, New York, New York.

1955

Jan. 10-14—**Society of Automotive Engineers,** annual meeting and engineering display, Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Michigan.

Jan. 17-19—**Pipe Line Contractors Association,** Statler Hotel, Los Angeles, California.

Feb. 13-17, 1955—**American Institute of Mining and Metallurgical Engineers,** annual, Conrad Hilton Hotel, Chicago, Ill.

Feb. 25—**Natural Gasoline Association of America,** Permian Basin regional, Scharbauer Hotel, Midland, Texas.

March 9-11—**American Petroleum Institute,** Southwestern District, Division of Production, Jung Hotel, New Orleans, Louisiana.

March 20-23—**American Institute of Chemical Engineers,** Kentucky Hotel, Louisville, Kentucky.

April 13-15—**Natural Gasoline Association of America,** annual, Baker and Adolphus Hotels, Dallas, Texas.

April 19-21—**Southwestern Gas Measurement Short Course,** University of Oklahoma, Norman, Oklahoma.

May 1-4—**American Institute of Chemical Engineers,** Shamrock Hotel, Houston, Texas.

May 14-22, 1955—**Deutsche Gesellschaft fur Chemisches Apparatewesen,** chemical plant and apparatus exhibition and congress, Frankfurt am Main, Germany.

June 6-15, 1955—**Fourth World Petroleum Congress,** Rome, Italy.

Sept. 12-16—**Instrument Society of America,** National Instrument conference and exhibit, Los Angeles, California.

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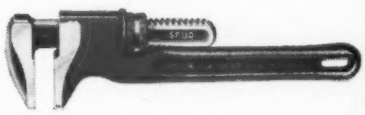

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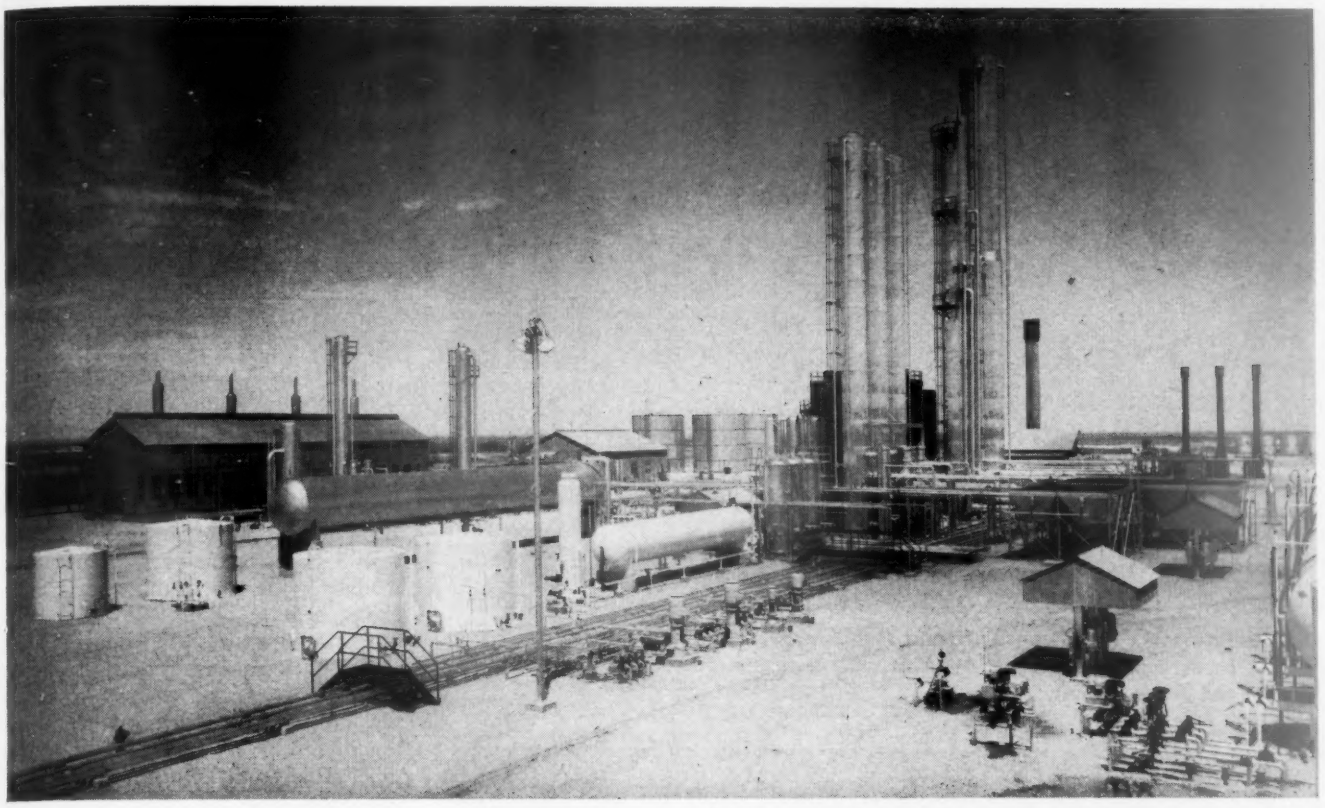


FIG. 1. View of the original plant, before addition of deisobutanizer and related facilities. Towers are: (left to right), debutanizer, depropanizer, deethanizer still and absorber.

Eight Fields Supply One Ultramodern Gasoline Plant

With no reabsorber, no recompressor, make-tanks 15 miles from fractionators, this plant shows the latest in design and operation

ARCH L. FOSTER*

ALL gasoline plants have "make tanks," but a plant where the make-tanks are 15 miles from the fractionators is something different.

Many gasoline plants serve one field, or part of one field; some handle the gas from two or three fields; but one plant that takes care of eight fields in a single general area — is something different.

And a plant that requires only 1 gpm of water for each 300 gal per day of product in a semi-desert area — is important.

And a plant that recovers practically all butanes and heavier, and 94-95 per cent of propane, all without a single reabsorber or a recompressor, gives food for thought.

Among other interesting things about this plant, that of Reef Fields Gasoline Corporation and Skelly Oil Company, in Howard and Borden Counties, central West Texas, is that the water for makeup comes from 5 wells drilled 9 miles from the plant, brought to it in a 6-in. line. And the LPG made at the plant, during slack periods of summer when propane and butane are used less than in winter, is being stored against winter's over-demand, in leached-out salt deposits 900-1300 ft underground, dissolved out with water that has been used twice already in other industrial plants, and that reached the surface first from wells 50 miles from the gasoline plant storage caverns.

*Editor, Refining, Petrochemical and gas processing edition.

EXCLUSIVE

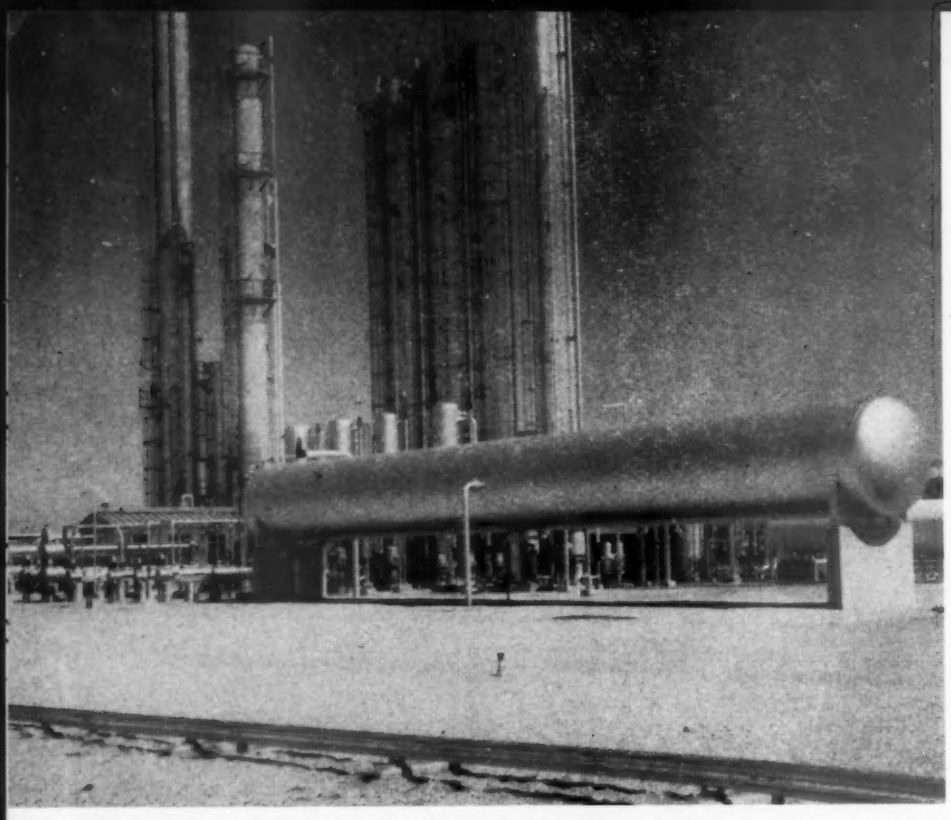


FIG. 2. Raw make-tank, long horizontal tank in foreground, with process towers in background. Left to right: Absorber, still, deethanizer, depropanizer, debutanizer, and deisobutanizer.

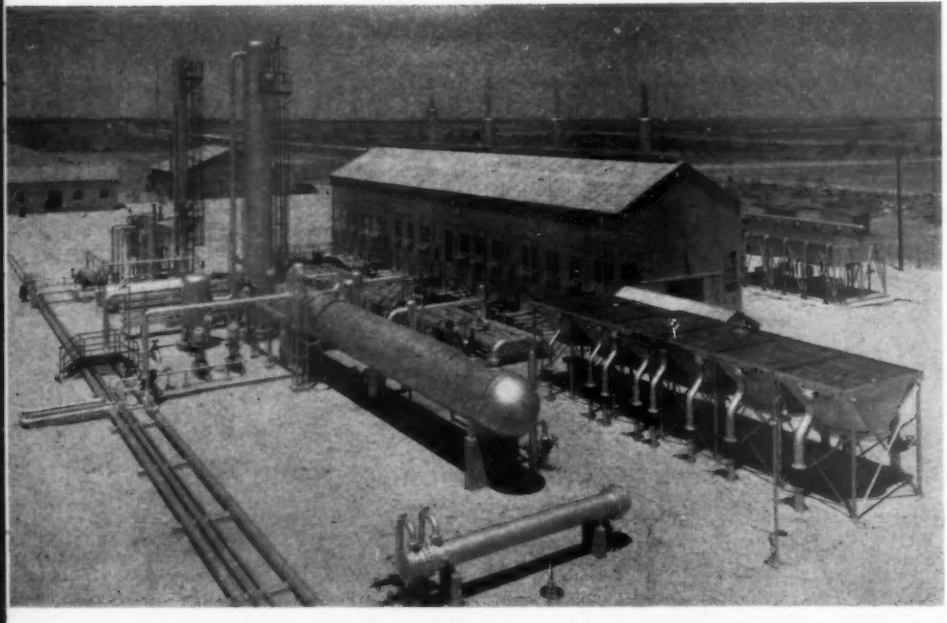


FIG. 3. East Vealmoor field compressor station in large building; with air coolers right and condensate surge tank in center.

The group of fields tied into this plant system extended more than 30 miles across the country, and the gas is handled by nearly 200 miles of pipe line. These 8 fields include Vealmoor and East Vealmoor, Good field, Oceanic field, North Luther field, Reinecke and Hobo fields, and South Von Roeder field, covering the entire oil and gas production in this area. Part of these fields are in Howard County, part in Borden County. For example, the field named Hobo does not commemorate any famous knight of the road, but is made from the first syllables of the two countries, *Ho*ward and *Bo*rden, the field lying close athwart the county line.

The plant has a nominal or design capacity of nearly 34,000,000 cu ft, but has handled as much as 38,000,000 cu ft, with a staff of 55 persons, including clerical staff and shipping terminal personnel. The compressor stations are designed also to meet the capacity needs of the different fields. Good field has 1540 hp in compressors. Two Clark units of 660 and 880 hp handle all the gas production. The Vealmoor field station has 3 Clark units totalling 2280 hp, and one 330 hp Beaird package compressor unit which take care of gas from Vealmoor, Oceanic, and North Luther fields.

Reinecke field is equipped with 4 units of 2860 compressor hp, handling the gas produced in that and the Von Roeder fields. Little Hobo field has two 330 hp package compressor units moving its output. Altogether these fields extend more or less 30 miles in an approximate arc through the 2 counties.

The Delta Engineering-built central compressor station and gasoline recovery plant in the East Vealmoor field is equipped with 4 compressors, with a total of 2860 hp. Each field collecting system draws the gas from the separators at a low pressure and raises it in 3 stages to the pressure necessary to deliver the gas to the central processing unit at about 475 psig. Field separator pressures are about 15 psig, with a back pressure regulator on each separator to guard against extremely low pressure and oil entrainment. Altogether some 65 miles of lightweight pipe, sized from 12 in. to about 3 in., are employed, all protected against corrosion by a Fibreglas coating overlying a coat of enamel.

All this compressed gas enters a condensate "knockout" tank at the plant, and some idea of the richness of the gas is obtained when it is realized that about 40 per cent of the nearly 300,000 gal per day of liquid products is recovered in this tank. Of course in the gas gathering-compressing system inlet gas is scrubbed while water condensed in compression is removed via interstage and final separators, keeping water out of the system from that point on. Also, the system employs air coolers on gas, jacket water on compressors, and lubricating oil. The main compressor unit at East Vealmoor, however, uses water, available there, for cooling the gas and lubricating oil.

Interstage gas is maintained in the winter at a temperature above that of gas hydrate formation by the use of automatic temperature control regulators; these activate a shutter arrangement on the interstage cooler units. By the same system the gas in the interstage steps is held above hydrocarbon dew point.

All compressor stations are so designed as to require the minimum of personnel attention. A somewhat unique system is the use of suction pressure recorder-controllers which by means of "positioners" vary individual compressor speeds over a given range,

determined by the gas load at a given instant; this action is individual, varying the speed of each compressor independently of all others. In addition automatic control flares excess gas pressure; shuts down the engines for high liquid level in scrubbers, high cooling water temperatures, low oil pressures, high pressure in discharge or low suction. A daytime staff only is required normally for the compressor operations.

Further precautions against malfunctioning and operating failures are made by the installation of a chemical pump at each compressor station for a two-fold purpose; it injects glycol to meet such weather conditions as produce hydrate formation; it also is used to force in a corrosion inhibitor to minimize hydrogen sulfide corrosion.

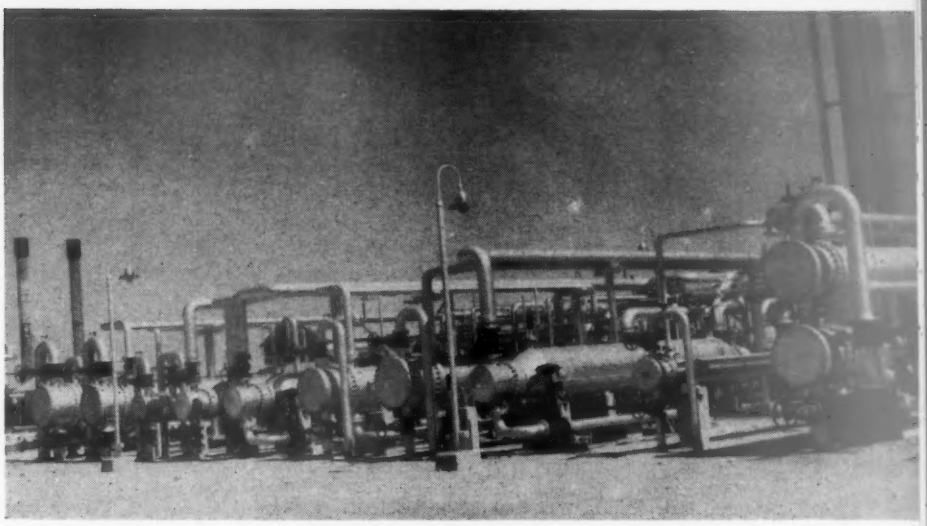


FIG. 4. Batteries of various heat exchangers for the recovery facilities.

Process Routine, Recovery

Beginning from the exit gases from the condensate tank (no treatment is used here to remove hydrogen sulfide) the gas passes to the absorber at 475 psig from which the stripped gas goes to El Paso Natural Gas Company. The controlling factor in the plant's high recovery efficiency, as will be discussed later, is the fractionating absorber. This absorber is propane refrigerated; 1 still for rich oil only is installed and used. In connection with this still are 3 steam boilers that take heat from the 525 F lean oil from the still bottom, and from the stripped vapors.

Liquid recovered in the condensate surge tank is sent, without sulfur removal treatment, to the deethanizer where it joins the distillate from the rich oil still; of this distillate the following discussion will clarify the operation. Partially denuded compressed gas from overhead the condensate surge tank passes to and enters the ethanolamine unit, where the hydrogen sulfide is removed quantitatively by absorption by monoethanolamine. From this step the essentially sulfur-free gas goes to the absorber at approximately 475 psig. Residue gas from the absorber overhead is sent directly to El Paso Natural's booster station where it is dehydrated and compressed to transmission line pressure.

The absorber oil is a low molecular weight product, 180 mol wt; it goes into the absorber at about 60 F, at the rate of 340 gal per minute, and in passing downward reaches the top intercooler at about 85 F, is chilled to about 60 F and is returned to the column. Eighteen trays below is the lower intercooler where the warmed absorption oil is again cooled from about 85 F to 60 F. Each of these intercoolers uses water to reduce the temperature, then a propane expansion chills to bring the temperature back to 60 F. The rich gas enters at the ninth tray from the bottom and the 9-tray stripping section in the absorber base eliminates all methane and most of the ethane; this eliminates reabsorbers and recompressors. Heat is supplied to reboiler by hot lean oil.

From the bottom of the absorber the rich oil goes to the still, a single-stage rich oil stripper design, after heating in a direct-fired heater (Fig. 6) to about 500 F. Some unique items are included in this still. It operates at 235 psig, because the heavy material is "knocked out" in the condensate surge tank; this enables operation at temperatures high enough to generate steam profitably in waste heat generators. Little if any hexane or heavier goes to the absorber.

The most careful analyses of the lean oil show no hexanes or any lower-boiling hydrocarbons in this stripped oil. One of the steam generators utilizes the heat from the stripper section va-

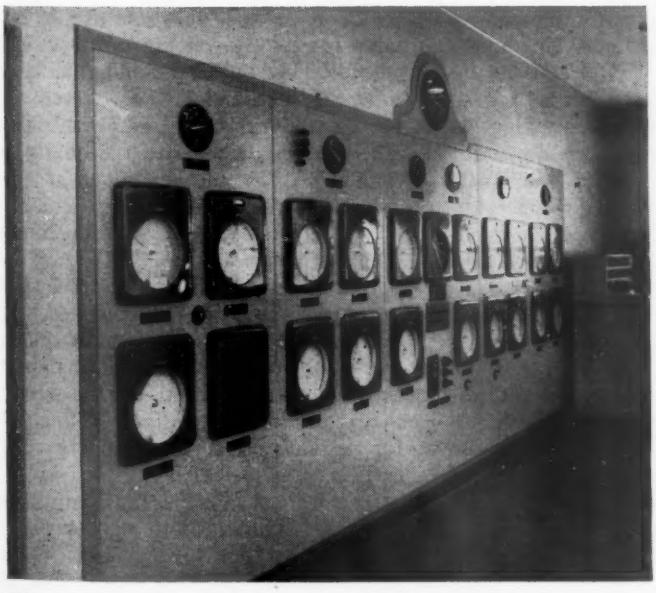


FIG. 5. Control panel for the gasoline plant proper.

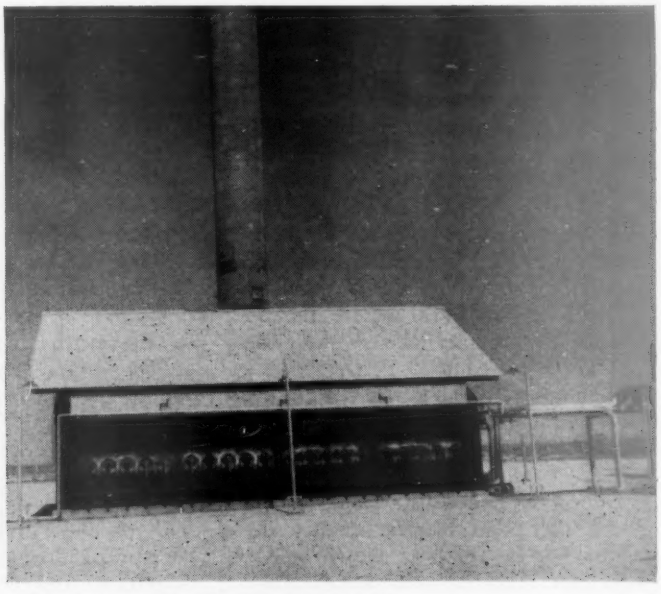


FIG. 6. Alco rich oil direct-fired heater.

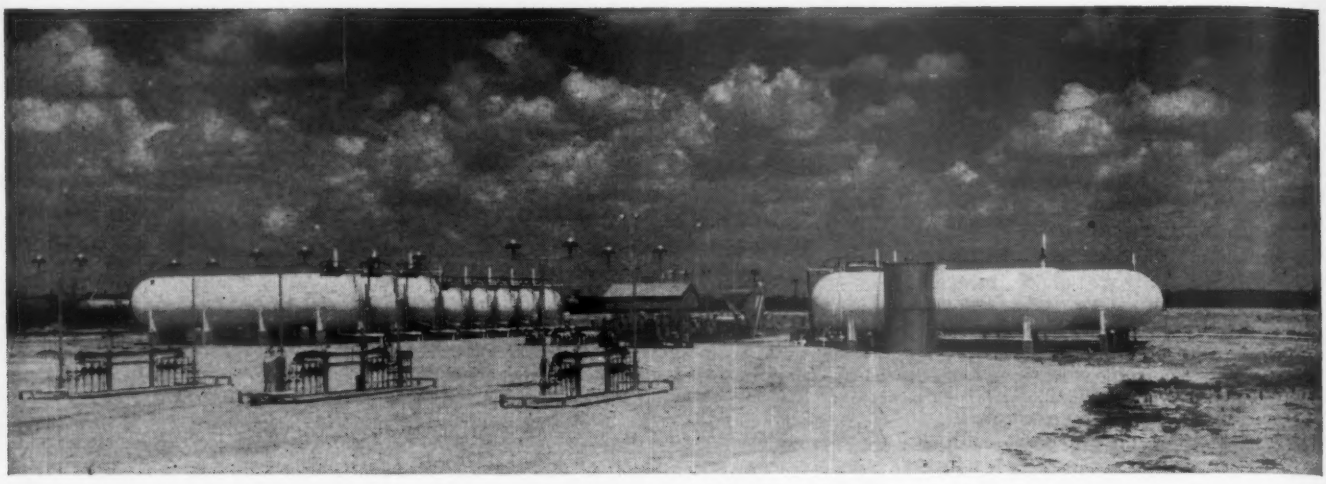


FIG. 7. Storage and loading terminal 15 miles from the main plant, with a truck loading spot in the foreground, LPG tanks at right, and propane dehydrators in center background between the two batteries of tanks.

pors to make 35 psig steam for use in fractionator reboilers. Another steam generator takes heat from the circulating reflux while the third is heated by the hot still bottoms (lean oil). These waste heat steam generators produce an average total of nearly 20,000 lb of steam per hour, under present operating conditions.

Some of the stripped hot lean oil passes through the absorber reboiler where the rich oil is heated to about 280 F, and thence all lean oil is cooled to 60 F by passing through the deethanizer feed preheater, water coolers, and a refrigerated chiller. Sufficient surge capacity is available in the base of the absorber and still so that no surge tank is necessary. By this means it is possible to maintain still pressure on the lean oil pump suction at a substantial reduction in pump power requirements. The net result of all this steam generating is two-fold; it provides about half the steam required for the plant, as heat savings; it reduces by about one-third the cooling system capacity of the plant, saving both ways.

Unconventional procedures dictated the selection of a single, cross-flow cooling tower instead of an induced draft tower. West Texas air is dry, and the wet bulb temperature is very seldom above 70 F, in a few instances for very short times as high as 72 F. By using the single cross-flow unit, and re-circulating part of the water from the side of the tower where the air comes in — air inlet face — water can be cooled to about 75 F, in quantity enough to supply the lowest temperture requirements of intercooler and lean oil cooling units. In winter little if any propane cooling is needed in this area for this plant, hence the system for supplying the plant electric energy demands was modified as shown below.

Design needs for power for the plant call for 3 gas-engine generators, each rated at 280 kw; a spare must be provided always, especially in a unit well away from public source of power. So a spare was provided to serve both the propane refrigeration system and the plant's power supply. A 400 hp engine drives the spare generator set; it is also connected to a propane compressor which it operates when refrigeration is required. When compressing propane the generator is disconnected, and vice versa, so that substantial savings are effected in overall investment and equipment.

Because of the systematic way in which inspection and repair cycles can be arranged on modern dependable electric generating units, this refrigerator-generator utility spare can be used to produce electrical energy in winter, when no refrigeration is required, while the three regular units are down for overhaul, each in turn.

Analogously, the boiler requirements, over and above the waste heat boilers heated by waste heat from the still streams, amounts to only about 18,000-20,000 lb per hour. This added steam is supplied by three 150 hp oil field type boilers, rated at 275 psig, of which one is a spare, taking its turn when other boilers are down for inspection-repair, or when the waste heat boilers are also down. Since temperature needs are low, 50 psig is standard pressure for plant steam used as a heating medium.

Returning to the new product stream, overhead from the still, this is condensed and sent to a separate surge rundown tank. Both this and the primary condensate liquid, knocked out in the condensate surge tank, combine in the deethanizer column. This tower is a 30-tray design, operates at about 500 psig and with a 250 F bottom temperature, 155 F top. The small amount of ethane passing over this 'cleanup' tower returns to residue gas.

Deethanizer bottoms are sent to the depropanizer, a 32-tray column that is run at 275 psig, 255 F bottom and 132 F top temperatures. Propane recovered overhead, 94 per cent or more of the total propane content of the raw gas, is sent directly to storage, generally to the caverns at the loading point, 15 miles away. Propane tower bottoms are pumped to the debutanizer tower, also of 32 trays, operated at only 125 psig but with 230 F bottom and about 150 F top temperatures. This tower bottoms is debutanized natural gasoline which is then blended with normal butane through means of a ratio flow controller to obtain the regular natural gasoline product, ranging normally from about 14 to 26 lb Reid vapor pressure, depending on requirements for the buyer. Again this stream goes directly via pipe line to the storage loading terminal at railhead on Highway 80 and the Texas and Pacific railway.

The butane stream overhead from the debutanizer is now sent to the "butane splitter" tower, installed in the spring of 1954 after the plant had been otherwise completed. This tower has 100 Turbogrid trays, is very highly efficient, and has shown the ability in regular service to operate well at considerable overload. Normally it is operated at 135 psig, a top temperature of 154 F and bottom of 174 F. Off the bottom comes normal butane and a portion of the n-butane is blended with the natural gasoline stream to obtain the vapor pressure wanted at any given time. Surplus normal butane above that required for blending gasoline and for current sales is stored underground as is surplus propane.

The storage and loading terminal is located 15 miles south of the plant, 8 miles east of Big Spring, Texas. Three pipe lines are installed from plant to terminal, one 3-in., one 3½-in., and

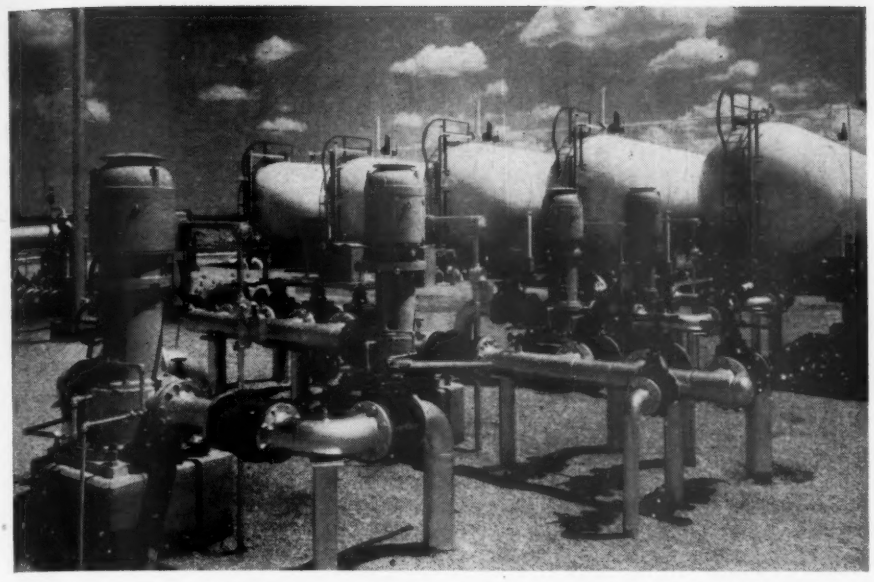


FIG. 8. Product loading pumps in foreground, butane and LPG tanks in background at loading-storage terminal.

one 4-in. line. Two handle propane and butane. One line carries gasoline and isobutane in turn, batchwise. In the 3½-in. line handling isobutane and gasoline, a gravity-sensing device, an Ohmart unit, employing a radioactive material as detecting agent, determines the change in gravity in the line when the stream of one product is ending and the beginning of the other product stream is entering the detecting instrument, enabling the operator to switch receivers when the product changes. This is a new device with very wide possibilities.

The isobutane and natural gasoline goes via pipe line directly to the refinery of Cosden Petroleum Corporation, about 4 miles away, for processing in that company's alkylation unit to make alkylate for aviation fuel. If called upon to deliver to other buyers, both natural gasoline and isobutane can be handled in storage available at the terminal.

Above ground storage at the terminal includes three 1250 bbl gasoline tanks, two 1000 bbl pressure storage tanks for normal butane, five 1000 bbl tanks for propane, and three 1000 bbl tanks for propane-butane mixture and/or isobutane. All these are horizontal cylinders. For underground storage, two "wells" are completed, one each for propane and butane. That is, the caverns are leached out with water derived from Big Spring sewage via Cosden Petroleum's process condensers, ready to receive and are now charged with liquid product up to 2,000,000 gal each. Three other wells are in various stages of completion while a sixth started drilling in early June.

Details of specifications and compositions of products vary widely, of course, depending on market requirements. The accompanying tabulations show typical analyses of the raw gas, stripped gas (residue gas), and of average products. Total production of liquid products ranges up to some 300,000 gal per day, amount depending on gas throughput.

Corrosion Precautions

To combat corrosion, use is made of only one stainless steel exchanger tube bundle, that used for the hydrogen-sulfide-rich amine solution in the sulfur removal unit. Tower trays in the amine desulfurizer are 304 stainless steel. Chemical inhibitors are used in gas lines from the fields and are used in the natural gasoline line to the terminal from the plant.

Water for steam and process comes from five shallow wells about nine miles from the plant; a sixth well may be drilled if it proves necessary. A phosphate organic inhibitor is used in the water transfer line to prevent corrosion by the raw water. This water is softened at the plant by a zeolite process along with an iron removal unit, that employs the catalytic oxidation action of manganese dioxide, MnO_2, and the water contains enough dissolved oxygen to carry on the oxidation reaction.

Water Conservation

In all semi-desert areas such as midwest Texas, water supply is of paramount importance. Water conservation is critical and in recent years some interesting developments have been made in air-cooling as auxiliary to water cooling. In this plant air cooling systems are installed as condensers on the (desulfurizing) amine regenerator overhead, on overhead vapors from the depropanizer, debutanizer and deisobutanizer. The lubricating oil, gas, and jacket water cooling units are air-cooled forced draft also. In only one instance is a final water cooling unit used, that in the East Vealmoor field compressor final stage cooling unit, to make as efficient as possible the gasoline plant input separator.

In addition, water for the steam generator is all condensate, with minimum makeup, if any at all is needed. Normally additional condensate is deaerated and sent to the boiler feedwater tank. As a final conservation measure, all water condensed from streams in "knockout" drums and accumulators is collected in a tank; oil is separated carefully in this tank and the oil-free water is drawn from the tank bottom and sent to the boiler feedwater tank.

To simplify maintenance and inspection, construction, and to aid both flexibility and revamping of any part of the plant system, all pumps are installed alongside the units served, outdoors. Mechanical seals are installed on all centrifugals. Process pump equipment is driven by electric motors, vertical centrifugal design, except for the lean oil pumps which are of the piston type and are driven by gas turbines exhausting to the plant fuel gas system. The vertical centrifugal cooling water pumps are driven by back-pressure steam turbines on low pressure exhaust steam. Pipe lines are installed in all parts of the plant on concrete piers one foot above ground level with the exception of water lines which are below ground level. * * *

TABLE 1. Reef Fields Gasoline Corporation, East Vealmoor Gasoline Plant.

	Analyses Mol Per cent					
	Inlet gas	Residue gas	Propane product	Isobutane product	N Butane product	14# RUP natural gasoline
Hydrogen sulphide	.03	.....	.....	.....	.....	.....
Carbon dioxide	.87	0.10	.....	.....		
Nitrogen	2.90	4.10	.....	.....		
Methane	48.63	68.68	.....	.....		
Ethane	18.63	25.65	2.90	.....		
Propane	16.75	1.40	96.52	2.70		
Isobutane	1.30	.07	0.58	96.30		
N-Butane	6.43	.....	.....	1.00	99.40	6.08
Isopentane	1.19	.....	.....	.....	0.60	24.83
N-Pentane	1.39	.....	.....	.....		29.38
Hexanes	1.88	.....	.....	.....		39.71
Total	100.00	100.00	100.00	100.00	100.00	100.00

XUM

GAS CONTRACTS NEED STREAMLINING

Numerous types, kinds, and forms of purchase and sales contracts in use today are contradictory and confusing — standardization would smooth procedures and prevent disputes

C. D. ATTAWAY

FOR the past few years, the growth and importance of the natural gas industry has been so rapid and changing that most major gas companies find themselves involved in many types, kinds, and forms of gas purchase and sales contracts. Some are highly involved and complicated. Others are obsolete and antiquated.

This confused and contradictory condition leads to arguments, disputes, and even law suits. Accounting departments find themselves faced with almost impossible procedures resulting from different contract requirements involving identical gas in common deliveries and receipts.

Casinghead Gas Contract

This condition arose a number of years ago when casinghead gas began to acquire importance for natural gasoline extraction. At that time the Natural Gasoline Association of America made a wise and practical step when it standardized the basis of payment by adopting a common form that incorporated tables and charts whereby amounts of residue and royalty due the seller could be determined. The 1939 revision of the NGAA casinghead gas contract is still the basis of many present day casinghead gas agreements. Certain amendments are usually present.

This contract failed to provide for the extraction of products other than natural gasoline, however, and as LPG products such as butane and propane have increased in importance and expanding markets have developed for these, it became necessary to amend the contract form to provide such settlement. This was done at the discretion of the parties involved by methods of their own choice.

It further developed that the price ranges for natural gasoline used in the standard contract form began to differ radically from actual market quotations, and increased efficiency in plant operations and gallon per minute testing began to result in higher natural gasoline yields from casinghead gas. This brought about other modifications and amendments, such as the so-called "Fort Worth Curve," which provided slightly higher royalty percentages.

Another important development was the steady increase in value of the gas itself. Where once casinghead gas was only a small part of the total natural gas produced and usually so low in volume and hydrocarbon content that it was flared, the rising demand for gas to be delivered by nation-wide networks of pipe lines gave it new value and importance. Furthermore conservation authorities and gas producers found a profitable means for using heretofore wasted or flared gas.

This condition led to a closer look at the gas lost as a result of processing by comparing the value of gas itself against its value as products. In view of the fact that the standard NGAA contract form provided a percentage table listing the amount of gas lost as shrinkage and plant fuel, conditions began to arise where shrinkage and fuel exceeded these amounts due to the extraction of additional products such as butane and propane. At times the value of the gas lost was greater than the value of the products recovered. This called for contract modifications. As a result, there is no standard NGAA contract form today.

Gas Measurement Laws

A final development that complicated the contract was the enactment of "Standard Gas Measurement Laws" by several states. Early contracts were written on pressure basis ranging from 2 lb plus 14.7 atmosphere to 14.4 lb absolute. Even the states themselves could not agree on a standard pressure base and they range from 14.65 lb absolute to 15.025 lb absolute.

More stringent requirements and regulations became effective with the new measurement laws and such things as super-compressibility, temperature, pressure, and gravity took on new value and meaning. As a result gas companies set up higher quality specifications such as moisture, corrosive matter, liquid hydrocarbon, and Btu content.

The final result today is that contracts are more binding and longer term agreements with precise specification requirements. Measurement errors alone in large volumes could mean large losses. Combining present day

No. ..... STANDARD FORM REVISED Adopted April 4, 1939

CASINGHEAD GAS CONTRACT

FROM

.....

.....

TO

.....

.....

Dated ....., 19.....

Lot ..... Block ..... Addition .....

Section ..... Township ..... Range .....

..... County, ...

No. of Acres ..... Term .....

STATE OF .....
COUNTY OF ..... } ss.

This instrument was filed for record on the .....day of ....., 19....., at .....o'clock.....M., and duly recorded in Book ....., Page .....of the records of this office.

.....
County Clerk—Register of Deeds

By .....
Deputy.

When Recorded
Return to .....

.....

EXCLUSIVE

*Arkansas Louisiana Gas Company.

contracts with old existing contracts in a single operation or plant and covering the operational requirements has resulted in a complicated accounting problem. The present day contract must contain the many accounting and legal technicalities necessary to provide equitable and fair settlement. As a result, lengthy and detailed documents cover the modern gas day transactions. It is essential that they contain all the elements relative to each of the factors previously mentioned.

Elements of a Gas Contract

A contract by definition is a "meeting of the minds" of competent parties. The written form is essentially an expression in detail of an oral agreement.

There are an number of major elements necessary to every gas transaction and these will be broadly described under the headings that follow.

Preamble. Some contracts start with a title page listing the parties and location of properties covered, followed by a page of contents listing sections by title and page number.

Other contracts open with a formal introduction stating the parties, their intent, the effective date and providing the payment by each party of some token legal consideration, or even an agreement for and in consideration of the premises and mutual covenants contained in the contract.

Many agreements are contingent on future actions of the parties, such as the buyer being able to obtain governmental approval of a proposed pipe line by a certain date, or the seller installing compression facilities within a specified time. When these contingencies are included, they are usually incorporated in the contract introduction.

Definitions. A section often incorporated is one that defines important terms and phrases of the contract such as type of gas, dedicated reserves, accounting day, accounting year, etc., over which there might possibly be some misunderstanding.

Description of properties. Gas to be sold under contract is, at best, of very indefinite quantity and is usually described as that underlying certain fields or leases and at times limited to that in certain productive horizons. When a number of leases are described, the description is usually in the form of an exhibit or attachment to the main body of the agreement.

A section is usually included binding the heirs, assigns, and successors. Seller encumbers the properties subject to performance of the contract, and buyer provides for the release of any well or wells from the operation of the contract for any reason.

Rights of seller. Seller usually reserves the rights to use gas from the dedicated properties for lease operation, and development, and operation of his and affiliated pipe lines, to process or have processed the gas for liquid hydrocarbons before delivery, and to operate his properties free of any control by the buyer.

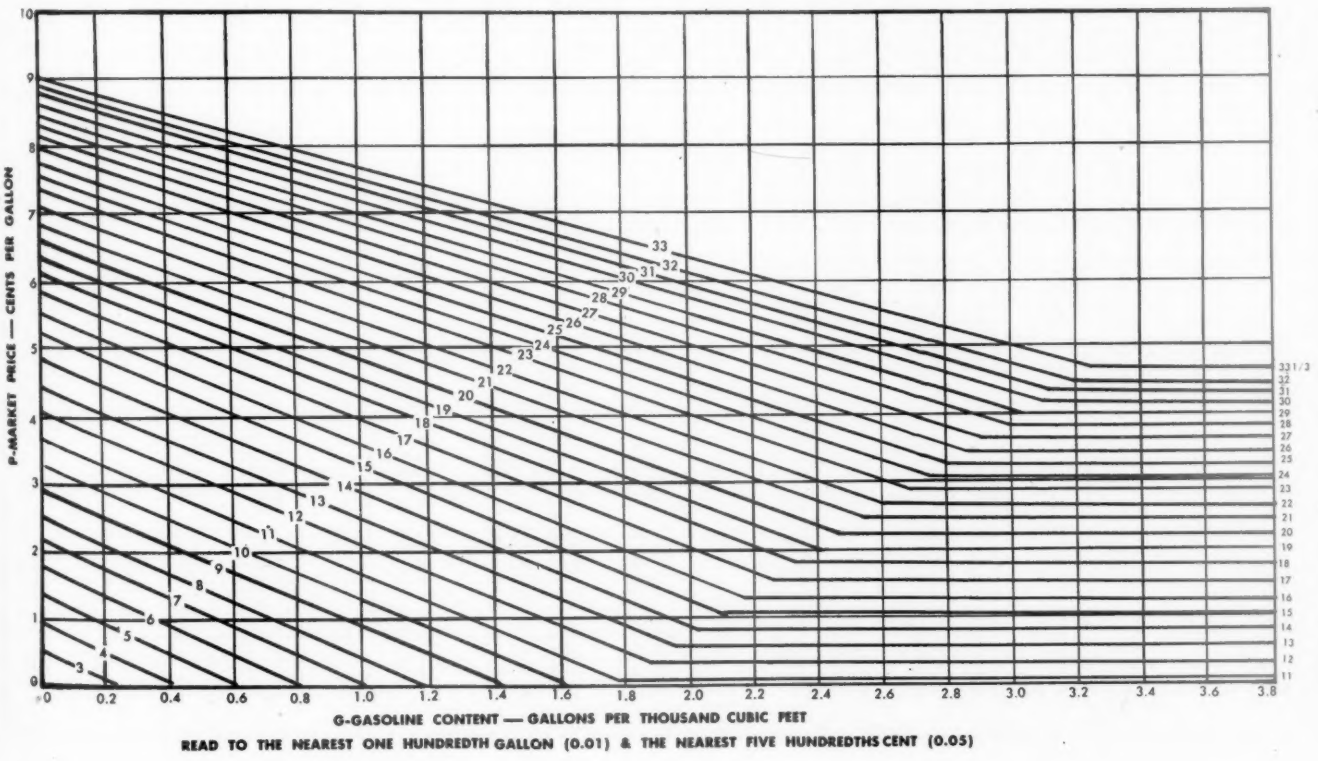
Date of contract and term. Effective date of most contracts is usually the date of final execution or a stipulated date. This date should be clearly defined for it is important in determining termination dates and making correspondence references.

Length of time the contract is to be in force is ordinarily a given number of days or years from a certain date. This date is usually the effective date of the agreement or the date of first delivery of gas. Sometimes, however, the agreement will terminate on a certain future date, irrespective of the elapsed length of time in days or years. In many instances, the agreements are intended to extend beyond the initial term and will do so, subject to cancellation on the anniversary dates.

Point of delivery. To remove any doubt as to where the title to the gas changes hands, the point of delivery is usually defined. It may be the outlet of the seller's dehydrator, separator, meter, at the well head, a valve on buyer's line, etc.

Delivery pressure and compression. For delivery into the buyer's facilities, the gas is usually required to have a stated minimum pressure. Generally, there is also a maximum stipulated pressure against which the seller may be obligated to deliver gas. Many agreements provide that should the gas pressure fall below the stated minimum, one or the other of the parties may have the right, but not necessarily the obligation to compress the gas to sufficient pressure. The prior right to compress usually falls to the seller but

The "Fort Worth Curve" table of royalty percentage.


P-MARKET PRICE — CENTS PER GALLON
G-GASOLINE CONTENT — GALLONS PER THOUSAND CUBIC FEET
READ TO THE NEAREST ONE HUNDREDTH GALLON (0.01) & THE NEAREST FIVE HUNDREDTHS CENT (0.05)

many contracts provide that should the seller not elect to compress the gas, the buyer may do so and reduce the contract price by an amount dependent on the number of stages of compression required. This ranges from ½ cent to 2 cents in most contracts.

Rate of delivery and quantities. To protect the seller against severe disruption of his normal field operations, contracts usually provide a minimum daily or monthly average quantity the buyer must take or pay for it if it is available. There is also usually provided a maximum average rate to prevent buyers from demanding large deliveries of short duration that would over-burden the seller's facilities. These rates of delivery are generally based on reserves, well or field allowables, and in some instances such as casinghead gas sales that are dependent on allowable oil production, any volume that may be available.

Price. Prime issue in consummating a contract of any kind is generally one of arriving at a mutually agreeable price. The seller naturally wants to obtain as high a price as possible and the buyer wants to pay as low a price as possible. Prices remain within reasonable limits, of course, due to the ever present situation of supply and demand.

Favored nations clause. In virtually all gas contracts, price is expressed as cents per thousand cubic feet. The simplest form of price clause is one in which the price is constant throughout the term of the contract. Current trends in gas prices, however, usually involve some type of automatic price increase or escalation over the life of the agreement. Some contracts include a so-called "favored nations clause" in which the buyer obligates himself to pay the seller as high a price for gas as he is paying any other seller within a given area. Another approach is to provide for price renegotiations at certain intervals during the term of the contract. The renegotiated prices are usually based on an average of a number of the highest gas sales prices paid by other buyers in the same area. Some recent agreements have incorporated price variations coupled to the national "Commodity Index."

The price clause of a typical gas contract may incorporate one or any combination of these methods of stipulating prices.

Taxes. Who will pay what taxes is carefully defined in most agreements. Generally, each party agrees to pay whatever taxes are applicable to his operations at the time of execution and the future taxes become the main issue.

Usual approach to this problem is for both parties to agree to share in the payment of any future taxes but not necessarily in equal percentages. In the case of certain taxes, the future increases will be borne two-thirds by buyer and one-third by seller. In all cases, extra high tax increases permits termination of the contract under certain circumstances.

Measurement. Most lengthy and detailed of all contract elements is usually that dealing with measurement. This is justly so, for to correctly define and measure so ambiguous a quantity as a cubic foot of gas requires a detailed procedure. The following are factors involved in the proper description of a MCF or thousand cubic feet of gas, the basic unit quantity of virtually all gas contracts:

1. *Pressure Base.* To obtain a basis for settlement and measurement, volumes are corrected to a stipulated pressure base. This pressure base has a material effect on volume and the term "MCF" is meaningless unless the pressure base is known. As an example, 1000 cu ft measured at a pressure base of 15.025 psia are equivalent to only 900 cu ft measured at a pressure base of 16.7 psia all other factors being equal. Recent legislation by Texas and Louisiana has resulted in the establishment of standard pressure bases of 14.65 psia and 15.025 psia respectively. Contracts prepared subsequent to the establishment of these standards incorporate the applicable pressure base in their measurement provisions and many then existing agreements have been amended to comply with the new standards. A temperature base of 60 F, and an assumed atmospheric pressure are also usualy provided in addition to the pressure base.

2. *Specific Gravity.* As the specific gravity of the gas enters the calculations of volume from orifice meter readings, provisions are generally incorporated that state how this gravity will be determined. Periodic measure-

The NGAA residue table.

Percentage of Casinghead Gas Remaining as Residue after Extraction of Gasoline and Plant use Based upon Gasoline Content in Gallons per 1,000 Cubic Feet (G. P. M.).

G.P.M.	%	G.P.M.	%	G.P.M.	%	G.P.M.	%	G.P.M.	%	G.P.M.	%	G.P.M.	%	G.P.M.	%
00	0	1.50	78.00	3.00	63.40	4.50	50.00	6.00	38.30	7.50	28.30	9.00	19.20	10.50	11.00	12.00	3.50
.05	93.10	1.55	77.50	3.05	62.95	4.55	49.65	6.05	37.90	7.55	28.00	9.05	18.85	10 55	10.75	12.05	3.25
.10	92.60	1.60	77.00	3.10	62.50	4.60	49.30	6.10	37.50	7.60	27.70	9.10	18.50	10.60	10.50	12.10	3.00
.15	92.10	1.65	76.50	3.15	62.00	4.65	48.85	6.15	37 20	7.65	27.30	9.15	18.20	10.65	10.25	12.15	2.75
.20	91,60	1.70	76.00	3.20	61.50	4.70	48.40	6.20	36.90	7.70	26.90	9.20	17.90	10.70	10.00	12.20	2.50
.25	91.05	1.75	75.50	3.25	61.00	4.75	47.95	6.25	36.55	7.75	26.70	9.25	17.60	10.75	9.75	12.25	2.30
.30	90.50	1.80	75.00	3.30	60.50	4.80	47.50	6.30	36.20	7.80	26.50	9.30	17.30	10.80	9.50	12.30	2.10
.35	90.05	1.85	74.50	3.35	60.15	4 85	47.15	6.35	35.80	7.85	26.20	9.35	17.05	10.85	9 25	12.35	1.85
.40	89.60	1.90	74.00	3.40	59.80	4.90	46.80	6.40	35.40	7.90	25.90	9.40	16.80	10.90	9.00	12.40	1.60
.45	89.00	1.95	73.45	3.45	59.30	4.95	46.35	6.45	35.10	7.95	25 50	9.45	16.50	10.95	8.75	12.45	1.40
.50	88.40	2.00	72.90	3.50	58.80	5.00	45.90	6.50	34.80	8.00	25.10	9.50	16.20	11.00	8.50	12.50	1.20
.55	87.85	2.05	72.45	3.55	58.35	5.05	45.50	6.55	34.45	8.05	24 80	9.55	16.00	11.05	8.25	12.55	.90
.60	87.30	2.10	72.00	3.60	57.90	5.10	45.10	6.60	34.10	8.10	24.50	9.60	15.80	11.10	8.00	12.60	.60
65	86.80	2.15	71.50	3.65	57.40	5.15	44.75	6.65	33.80	8.15	24.25	9.65	15.50	11.15	7 70	12.65	.35
.70	86.30	2.20	71.00	3.70	56.90	5.20	44.20	6.70	33 50	8.20	24.00	9.70	15.20	11 20	7.40	12.70	.10
.75	85.75	2.25	70.50	3.75	56.55	5.25	43.85	6.75	33.15	8.25	23.65	9.75	14.95	11.25	7.20	.....	.....
.80	85.20	2.30	70.10	3.80	56.20	5.30	43.50	6.80	32.80	8 30	23.30	9 80	14.70	11.30	7.00	.....	.....
.85	84.70	2.35	69.60	3.85	55.75	5.35	43.05	6.85	32.50	8.35	22.95	9.85	14.45	11.35	6.75	.....	.....
.90	84.20	2.40	69.10	3.90	55.30	5.40	42.60	6.90	32.20	8.40	22.60	9.90	14.20	11.40	6.50	.....	.....
.95	83.65	2.45	68.65	3.95	54.80	5.45	42.25	6.95	31.85	8.45	22.30	9 95	13.95	11.45	6.25	.....	.....
1.00	83.10	2.50	68.20	4.00	54.30	5.50	41.90	7.00	31.50	8.50	22.00	10.00	13.70	11.50	6.00	.....	.....
1.05	82.50	2.55	67.70	4.05	53.85	5.55	41.55	7.05	31.15	8.55	21.70	10.05	13 35	11.55	5.80	.....	.....
1.10	81.90	2.60	67.20	4.10	53.40	5.60	41.20	7.10	30.80	8.60	21.40	10.10	13.00	11.60	5.60	.....	.....
1.15	81.40	2.65	66.70	4.15	52.95	5.65	40.80	7.15	30.50	8.65	21.10	10.15	12.75	11.65	5.35	.....	.....
1.20	80.90	2.70	66.20	4.20	52.50	5.70	40.40	7.20	30.20	8.70	20.80	10.20	12.50	11.70	5.10	.....	.....
1.25	80.40	2.75	65.75	4.25	52.15	5.75	40.15	7.25	29.85	8.75	20.55	10.25	12.25	11.75	4.85	.....	.....
1.30	79 90	2.80	65.30	4.30	51.80	5.80	39.90	7.30	29.50	8.80	20.30	10.30	12.00	11.80	4.60	.....	.....
1.35	79.45	2.85	64.90	4.35	51,30	5.85	39.50	7.35	29.25	8.85	20.05	10.35	11.75	11.85	4.35	.....	.....
1.40	79.00	2.90	64.50	4.40	50.80	5.90	39.10	7.40	29,00	8.90	19.80	10.40	11.50	11.90	4.10	.....	.....
1.45	78.50	2.95	63.95	4.45	50.40	5.95	38.70	7.45	28.65	8.95	19.50	10.45	11.25	11.95	3.80	.....	.....

ments by gravity balance, recording by gravitometer, or assuming a constant gravity are the most common methods employed.

3. *Temperature.* Flowing temperature, like specific gravity, is necessary to correctly calculate volumes and is usually determined by periodic readings of a mercury thermometer, averaging readings from a recording thermometer, or assuming a constant temperature.

4. *Supercompressibility.* Natural gas at elevated pressures deviates considerably from the behavior indicated by the Ideal Gas Laws and factors have to be applied to correct calculated volumes to actual volumes. To ignore this deviation, as was often done in many older contracts, results in a loss of revenue to the seller. Corrections for normal measurement pressures usually increase the actual volume by an appreciable percentage, dependent on the pressure, temperature, and gravity of the gas.

The Standard Gas Measurement Laws adopted by Texas and Louisiana, which set standard pressure bases, also include provisions requiring deviation corrections for all gas measured at pressures in excess of 100 psi and 200 psi respectively. Most contracts today have been drawn or amended to conform with these measurement laws and provide for deviation corrections determined from accepted tables or periodic tests.

5. *Heating Value.* The trend toward emphasis on the heating value of gas has led to the inclusion of provisions for periodic tests or recording calorimeter installations in most current agreements.

6. *Equipment.* The type of metering equipment, where it is to be placed, and which party is to operate it is generally carefully defined.

New rulings of Federal Power Commission with regard to independent gas producers need not affect the standardization ideas discussed in this article.

All contracts necessarily contain an escape clause that FPC rulings are paramount to stated terms.

7. *Record.* It is common practice to include provisions covering the length of time charts, test data, records, etc., to be kept and who is to keep them.

Quality. Quality specifications imposed on gas to be sold under contract are to minimize the danger of freezing and corrosion in the buyer's system and to insure that the gas will meet end consumer requirements. Following are gas characteristics covered in most agreements:

1. *Water Content.* The maximum moisture toleration is generally expressed as a number of pounds per million cubic feet or the equivalent dew point at a certain pressure.

2. *Corrosive Matter Content.* The maximum toleration of carbon dioxide is generally expressed as a per cent by volume while maximum permissible sulfur and hydrogen sulfide contents are usually expressed as the number of grains per 100 cu ft.

3. *Heating Value.* Gas must meet minimum heating specifications, usually expressed as Btu's per cubic foot. The value of 1000 Btu's per cubic foot seems to be more or less standard. Some agreements provide that contract price may be reduced if heating value is below that stipulated in the contract. In some instances, a limit has been put on the maximum permissible heating value.

Accounting and settlement. To establish a standard procedure for settlement, most agreements state a certain day of the month when payments by buyer for the previous month's purchases are due. In contracts under which the seller does the metering, provisions are included that obligate the seller to render invoices to the buyer a reasonable time before buyer's settlement is due. A section also provides for determining which party shall make royalty payments.

Warranty and indemnity. In order to free the buyer from any claims or disputes arising over title to the gas, most agreements incorporate provisions whereby the seller warrants title to all gas sold. Clauses also are generally provided in which buyer and seller each indemnify the other against damages arising from his own operations.

Force majeure. As protection for both parties, a "force majeure" or escape clause is generally provided that frees one party of any damage claims of the other in event he is unable to meet his contractual obligations due to causes over which he has no control, such as "acts of God," strikes, breakdowns, restraining orders, etc. When a party wishes to exercise his "force majeure" privileges, he is generally obligated to give written notice to the other party.

Regulatory bodies. Most contracts include provisions which subject operations of the parties to all applicable local, state, and federal laws. There are often additional provisions that permit the parties to terminate the agreement in event of unfavorable ruling by the

The NGAA table of royalty percentages.

Sales price of Gasoline in Cents per Gallon	Gasoline Content in Gallons per 1,000 Cubic Feet of Gas.												
	.0 to .25	.25 to .50	.50 to .75	.75 to 1.00	1.00 to 1.25	1.25 to 1.50	1.50 to 1.75	1.75 to 2.00	2.00 to 2.25	2.25 to 2.50	2.50 to 2.75	2.75 to 3.00	3.00 and above
	Percent												
0.5 to 1.0	5.	5.	5.	6.25	7.5	8.75	10.0	11.25	12.5	13.75	15.0	16.25	17.5
1.0 to 1.5	5.	5.	6.25	7.5	8.75	10.0	11.25	12.5	13.75	15.0	16.25	17.5	18.75
1.5 to 2.0	5.	6.25	7.5	8.75	10.0	11.25	12.5	13.75	15.0	16.25	17.5	18.75	20.0
2.0 to 2.5	6.25	7.5	8.75	10.0	11.25	12.5	13.75	15.0	16.25	17.5	18.75	20.0	21.25
2.5 to 3.0	7.5	8.75	10.0	11.25	12.5	13.75	15.0	16.25	17.5	18.75	20.0	21.25	22.5
3.0 to 3.5	8.75	10.0	11.25	12.5	13.75	15.0	16.25	17.5	18.75	20.0	21.25	22.5	23.75
3.5 to 4.0	10.0	11.25	12.5	13.75	15.0	16.25	17.5	18.75	20.0	21.25	22.5	23.75	25.0
4.0 to 4.5	11.25	12.5	13.75	15.0	16.25	17.5	18.75	20.0	21.25	22.5	23.75	25.0	27.0
4.5 to 5.0	12.5	13.75	15.0	16.25	17.5	18.75	20.0	21.25	22.5	23.75	25.0	27.0	29.0
5.0 to 5.5	13.75	15.0	16.25	17.5	18.75	20.0	21.25	22.5	23.75	25.0	27.0	29.0	31.0
5.5 to 6.0	15.0	16.25	17.5	18.75	20.0	21.25	22.5	23.75	25.0	27.0	29.0	31.0	33.3
6.0 to 6.5	16.25	17.5	18.75	20.0	21.25	22.5	23.75	25.0	27.0	29.0	31.0	33.3	33.3
6.5 to 7.0	17.5	18.75	20.0	21.25	22.5	23.75	25.0	27.0	29.0	31.0	33.3	33.3	33.3
7.0 to 7.5	18.75	20.0	21.25	22.5	23.75	25.0	27.0	29.0	31.0	33.3	33.3	33.3	33.3
7.5 and above	20.0	21.25	22.5	23.75	25.0	26.25	29.0	31.0	33.3	33.3	33.3	33.3	33.3

NOTE:—Each gasoline content and sales price division in the schedule above includes the smaller but excludes the larger figure.

Should any casinghead gas be delivered to Buyer by Seller at pressures adequate to process said gas through Buyer's plant directly and without the use of compression machinery by Buyer and Buyer's plant be equipped to handle such gas directly in said plant and should Buyer so utilize said gas, then the application "Percent" in the above schedule shall be increased by adding five (5) thereto, provided that in no such case shall the total percentage be more than 33.3%.

regulator bodies. The Federal Power Commission is often identified as such a body.

Arbitration. A provision seldom resorted to but usually included is one providing for arbitration of unsettled controversial issues by a disinterested party or parties. The arbitors generally selected are consultants or recognized authorities in related fields such as attorney, geologists, engineers and similarly qualified persons.

Miscellaneous and address of parties. Items not covered in the main articles of the contract are generally grouped in a miscellaneous section at the end of the agreement. This section usually includes mailing addresses of the parties, provisions covering assignability of interests and similar relatively minor details.

Signatures. To legally consummate the written agreement requires signatures of the parties or in case of corporations, authorized representatives. These signatures, usually properly witnessed and sometimes dated, complete the contract execution.

The contract is usually completely executed in duplicate, or in as many copies as there are parties in order that each party will have a copy of the original.

A gas contract is by no means limited to the aforementioned articles for there are as many ways to consummate a transaction as there are parties wishing to do so. There is a trend, however, in gas contract writing toward a more or less standard form as far as issues covered are concerned. The important details, of course, cannot possibly be standardized under the system of free enterprise which we know today.

Supplement — liquid hydrocarbon processing. In event gas purchased under the contract is processed by the buyer for manufacturing of products from the liquid hydrocarbons contained in the well production, the following supplement should contain the elements listed.

Identification. The first paragraph or statement should identify the contract date, properties covered, and parties by name. It should state the intent of buyer and agreement of seller.

Types of processing. There are several operating conditions under which well production may be processed. The contract should set out each condition and the settlement basis thereof. For example, normal operation of the delivery of both gas and condensate is a combined well stream into the plant.

A typical provision is as follows:

Combined Gas and Condensate Production.

When the total well stream is delivered into the plant for processing, settlement may be made to seller under either of these methods.

(A) Seller to receive a certain per cent of the value of products produced or manufactured from the gas delivered under the contract based upon his share of the potential field production as determined by field gallons per million tests. Value of the products is the "weighted average net sales price" to permit deducting such items as taxes, cost of blending agents, and chemicals.

In event non-connected wells or "outside" condensate, fluid or products are processed in the plant, their total shall be deducted from actual plant production before allocation.

(B) An alternate method is to pay seller for lease potential gallons of gasoline based on a NGAA gasoline content test, basing sales price on a *National Petroleum News* quotation for the area plus or minus a premium on the average price of 26-70 natural gasoline. The royalty percentage tables of NGAA are usually used ranging from 20 per cent for 2 cents gasoline to thirty-three and one-third per cent for 4 cents gasoline.

Butane and propane plant production is allocated on gallons per million to seller after deducting that quantity required to manufacture 26 lb Reid vapor pressure gasoline. The weighted average sales price per gallon is used and a royalty table ranging from 15 per cent for 2 cents gasoline to thirty-three and one-third per cent for 6 cents gasoline.

Under both of these provisions, it is agreed that seller should stand actual shrinkage and fuel as a result of processing the well production and in event gas is *not* processed, but by-passed raw around plant then the price per 1000 cu ft at the well paid for the gas shall constitute payment in full. Some contracts provide that total plant fuel and shrinkage shall not exceed a certain percentage of the total plant inlet or outlet.

When the method (B) is used, raw condensate produced along with the gas stream is paid for at the posted price in the field based upon liquid volume determined by fluid meter or gallons per million test.

Gallons per minute testing.

Gasoline.

The natural gasoline content of the gas is determined periodically, either quarterly or semi-annually, by the NGAA code and expressed in gallons per million on the pressure base given in the contract.

Condensate.

Quantity of condensate contained in the gas is determined by one of the following methods at the same interval of the gasoline tests:

(A) Split-stream or stinger tests.
(B) Portable full-scale separator tests.
(C) Fluid metering or gas-oil ratio test by meter corrected to atmospheric conditions.

These results to be expressed in gallons per million on the pressure base of the contract.

At least 10 days notice shall be given seller before tests and in case of a third party tester seller and buyer shall split costs. Retests to be paid for by party requesting same. In all tests, it is assumed that both buyer and seller may desire to have witnesses present and the contract provides for this condition.

Buyer's right to process. The contract normally provides that the gas will be processed, but does not require buyer to continue to process if uneconomic.

If gas or condensate contains objectionable liquid or solids unsuitable for processing, seller must separate, clean, or treat for removal before buyer is required to accept.

Gas by-passed around plant or condensate not processed shall not be included for allocating plant production or settlement.

Settlements. The usual type contract provides that buyer will pay seller for products on or before the 20th of the month, next following the one for which settlement is made.

Conclusion

Even the above factors and methods have variations depending upon circumstances that are favorable to either buyer or seller, however, contracts as a general rule can be written with many standard provisions and should be so drawn for the sake of congruency, common understanding, and simplicity.

A common error in most contracts today is the use of superfluous words, phrases, and expressions. Simple and exact language make a briefer and more concise agreement. Quite often contracts contain provisions and requirements for which there is no application. These only tend to confuse interpreters and complicate accounting.

It is quite obvious that contracts are always subject to amendment and renegotiation, so that problems can be met as they arise instead of anticipated or "second-guessed" and entirely misjudged.

Nothing will ever replace the right of seller and buyer to bargain and trade in open competition and no contract, however clearly written to conceal advantages, will be successfully enforced where one party or the other is unjustly injured. * * *

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The footage drilled by Hughes bits since 1909 exceeds 850,000,000 feet — or more than 20 times through the earth. This represents the industry's greatest rock bit drilling experience.

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That's why Hughes rock bits are recognized as the standard of the industry throughout the world. *This is a reprint of an advertisement run in 1951 with footage figures corrected to bring them up to date.*

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Talk

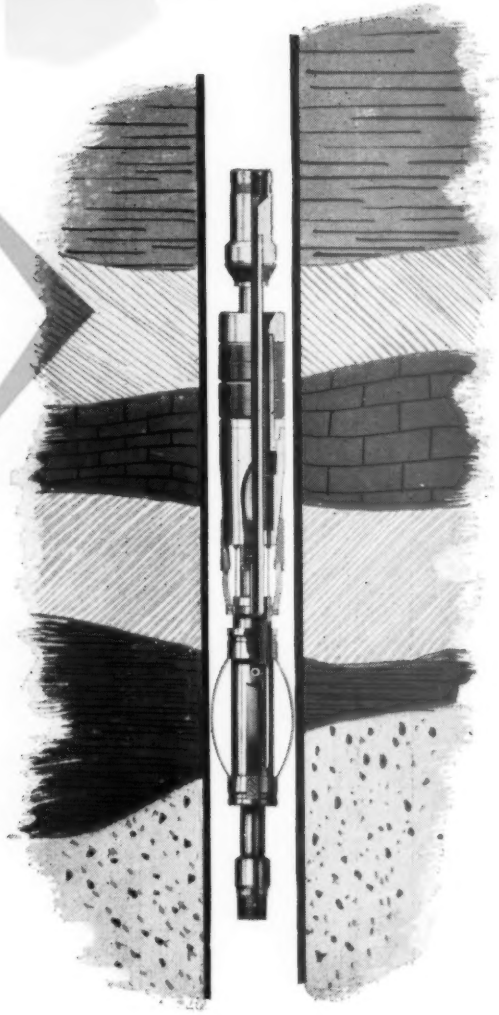
about performance here!

Words won't make a packer—but you can learn a lot about the bottom hole performance of Lane-Wells Packers by talking to the many operators who use them. Things like leakproof pack-off, positive setting, easy pulling, for example. There are reasons, of course; the controlled expansion of the packing element, whose special material doesn't "vulcanize" to the casing but springs back ready for resetting; the generous by-pass area of the circulation packers, which allows fast running in fluid and easy equalization of pressures before pulling; the valve seal which operates even with junk on the seat; the 'Slydeze' slips which don't 'freeze' to the cone; the lifting lugs which reduce compression of the packing element to eliminate sticking; the 'free-wheeling' cage—and the fact that among the 314 types and sizes of Lane-Wells Packers there's at least one which is tailor-made to do *your* job!

Lane-Wells Packers

Deliver

performance here!



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Exploration, Drilling, Producing

Cuban Venture Pending

Deep Rock Oil Corporation and Sterling Oil of Oklahoma, Inc., have announced a joint exploration and development program on approximately 5,200,000 acres of concessions in Cuba. Geological studies are now underway to determine the exact locations for initial wells, the first of which is scheduled to be drilled later this year.

Announcement follows closely the completion of the No. 1 Echevarria in Jatibonico Basin, Las Villas province, in the center of the island. This well, considered a significant oil discovery, was completed in May.

Cuba at present produces only about 230 bbl of oil daily, importing between 50,000 and 55,000 bbl daily to satisfy needs of the island. Cuba has been considered geologically favorable for production for years. It is anticipated that exploration could well result in another, but smaller, western Canada where Cretaceous sands are productive.

★ ★ ★

Offshore Test Abandoned

Stanolind's $1,000,000 dollar exploratory test, 25 miles east of Galveston, Texas, has been plugged and abandoned as a dry hole. Drilled to 14,000 ft from a platform in 60 ft of water, the failure was one of the few deep tests on the federally controlled portion of the continental shelf. Additional drilling in the area is currently being planned with Pure as operator in a partnership venture.

★ ★ ★

Department Set Up

Douglas Oil Company of California has announced the establishment of a new department of exploration and production to facilitate the exploration and development of crude oil properties. Department will be headed by Thomas A. Atkinson who will direct activities on the company's properties in California and Peru.

★ ★ ★

Shale Oils Found Suitable

Recent development of processes for the commercial extraction of oil from the nation's great deposits of oil shale (containing an estimated recoverable 500 billion barrels) has led the Institute of Gas Technology, Chicago, to investigate the use of shale oil in the production of high-Btu oil gases.

The oil gas yields from shale oil were found to be approximately the same as those obtained from petroleum oils of equivalent carbon-hydrogen ratio, and, when scrubbed and blended with inerts to the desired heating value and specific gravity, had equal or greater substitutability for high-methane natural gas than petroleum oil gases of the same heating value.

★ ★ ★

Texas Gas Keeps Program

The third year of a long range program designed to attract promising young graduates to jobs in the natural gas industry has just been completed by Texas Gas Transmission Corporation of Owensboro, Kentucky.

Twenty-two college students were enrolled this summer in an on-the-job training program whose purpose is to provide Texas Gas with a source of trained employees for the future. Trainees who show promise are re-employed each summer until graduation. They will be offered permanent positions after they receive degrees.

CLIP YOUR OWN DRILLING MANUAL

When completed the Drilling Fundamentals series now being published in The Petroleum Engineer will be a valuable and comprehensive handbook of rotary drilling.

Don't miss clipping the installments in each issue. The pages fit standard loose-leaf notebooks.

Drilling Fundamentals will include 55 articles written by those who know drilling operations and can describe them. Turn to **Page B-99** now and clip this month's chapters on **Drilling Fundamentals.**

California Drilling Off

Drilling operations through July show a decline of a little more than 7 per cent when compared to the figures for the same period in 1953. Specifically, total drilling operations through August 7 of this year as reported by California's Department of Natural Resources were 1464 wells. During like period of 1953, there were 1577.

★ ★ ★

AIME Plans Meeting

Fourteen technical sessions, each featuring the presentation of 3 or more technical papers, are scheduled at the fall meeting of the Petroleum Branch in San Antonio, Texas, October 17-20. Over 2200 petroleum engineers and 400 of their wives are expected to attend the annual meeting. Registration begins Sunday, October 17, at the Plaza Hotel headquarters.

★ ★ ★

Plan New Guinea Drilling

An Australian company, The New Guinea Gold and Petroleum Company will drill exploratory wells in the Sepik River area, near oil seeps noted by American troops occupying the country in the mid-1940's. Some evidence of prior exploration, probably Dutch, done before 1933 and prior to the definite location of territorial borders, is noted.

★ ★ ★

German Production Rises

The discovery of five new oil fields this year will increase West Germany's annual production of 17,500,000 bbl, about one third of the nation's requirements and 5 times the peak under Hitler. Already west Europe's largest producer, West Germany now has reserves of some 420,000,000 bbl and promises to become self-sufficient within the next 10 years.

★ ★ ★

Guiana Survey Planned

Plans for photo-mapping of a 38,000 sq mile area in Central British Guiana have been announced. Spartan Air Services Limited, Ottawa, Canada, was awarded the assignment. Two PV-1 Venturas will be used in the photo survey. The mission is expected to be a 3-months operation.

XUM

BAKER *Tools for International Operations*

BAKER OIL TOOLS INC. · BAKER · SERVING THE WORLD

Here are a few of the most outstanding Baker Oil Tools for 1954. Complete details, illustrations and specifications are in your new 1954 Composite Catalog, starting on Page 435, where many other important Baker Products will be found.

▶ No other product has proved so successful for so many applications as the BAKER RETAINER PRODUCTION PACKER, which can be set on tubing, drill pipe, or on a wire line. Look on Page 496 of the 1954 Composite Catalog to learn how it is used for single-zone or dual-zone production; as a squeeze tool for acidizing or cementing; as a tubing anchor and as a bridge plug.

▶ For placing cement slurry, plastic, acid or other fluids, the BAKER RETRIEVABLE CEMENTER provides a safe, positive "Hold-Down Type" Packer which operates mechanically rather than by fluid pressure. Look on Page 495 of the 1954 Composite Catalog.

▶ BAKER CASING BRIDGE PLUGS can be set on tubing, drill pipe, or on a wire line to provide either a permanent or a temporary bridge plug which prevents either upward or downward movement of fluid or gas. Many other advantages are described starting on Page 474 of the 1954 Composite Catalog.

▶ No other product can equal the efficiency of the BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE for safely floating-in and landing casing strings of any length. Removes bridges, washes the formation, and imparts a "whirling" action to the cement slurry which minimizes danger of channeling and affords the best opportunity for placing a uniform body of cement around the critical shoe joint. See Page 438 of the 1954 Composite Catalog for details.

▶ For successfully placing cement or fluid at the place where it will be most effective, the BAKER CEMENT RETAINER has been "standard equipment" in International oil fields for many years. Read of its many uses starting on Page 474 of the 1954 Composite Catalog.

▶ The BAKER CEMENT FLOAT COLLAR usually is positioned a joint or two above the shoe to serve as a stop for the cementing plug, as well as a "float" valve. Used with a Baker Guide Shoe in wells of average depth, or with a Baker Float Shoe where two floating units are desired in deep wells. The complete line of Baker Cementing Equipment is described in the 1954 Composite Catalog, starting on Page 438.

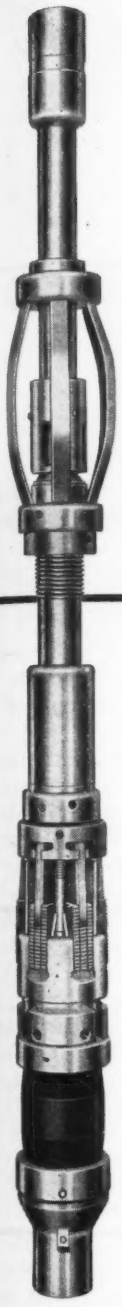
▶ The importance of having the I.D. of casing free from gun-shot burrs, hardened rotary mud and mill scale is evident from the rapidly increasing use of BAKER ROTO-VERT CASING SCRAPERS. Can be run easily and safely on drill pipe, tubing or a wire line, and leaves the "working surface" of casing clean and smooth for all future operations. Look on Page 517 of the 1954 Composite Catalog for details.

▶ When the time comes to center casing *positively*, and provide a uniform annular space for successful cementing, you need BAKER HINGE-LOK CASING CENTRALIZERS. Made in four ranges to exactly meet your casing programs, with many features not found in other centralizers. Interesting facts and illustrations start on Page 462 of the 1954 Composite (or Baker) Catalog.

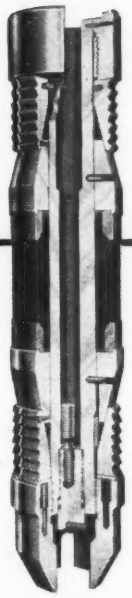
▶ Controlled removal of the mud cake throughout the intervals to be cemented is positive and safe when BAKER WALL SCRATCHERS are used. The "scratching" action is minimized while running-in, but the spring-loaded wires with maximum reach dig in for best results on the upstroke. See Page 472 of the 1954 Composite Catalog.

▶ Any drilling man will tell you how the BAKER DRILL PIPE FLOAT VALVE lengthens the life of wire lines and brake bands by relieving weight; how it prevents pulling "wet" strings; how it prevents or minimizes accidents in case the drilling string should part. See for yourself on Page 534 of the 1954 Composite Catalog.

Baker Retainer Production Packer Product No. 415-D

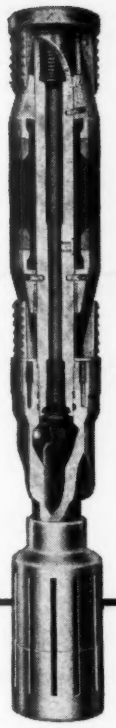


Baker Retrievable Cementer
Product No. 411-RT



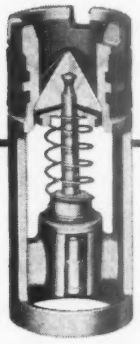
Baker Wire Line Bridge Plug
Product No. 400-N

Baker Cement Wash-Down Whirler Float Shoe
Product No. 120

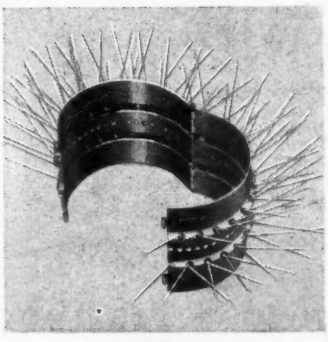


Baker Cement Retainer
Product No. 400

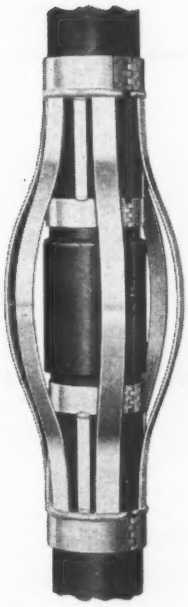
Baker Cement Float Collar
Product No. 101 M & F



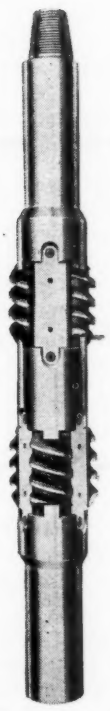
Baker Drill Pipe Float Valve
Product No. 4813



Baker Wall Scratcher
Product No. 900



Baker HINGE-LOK Casing Centralizer (H-25)
Product No. 9113



Baker ROTO-VERT Casing Scraper
Product No. 620-C

The Baker Section starts on Page 435 of your 1954 Composite Catalog; or if you prefer a separate BAKER Catalog, contact the office nearest you.

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Plan Drilling Contract

A proposed contract for oil drilling in Santa Monica Bay has been approved by the city council of Santa Monica and will be placed before the voters of that community on November 2. The contract would provide that drilling must be carried on 1 mile or more offshore and the city would receive a bonus of $500,000 plus royalty for the lease. Royalty would be determined by competitive bidding. The successful bidder would also have to pay $250,000 per year beginning 5 years after the first production. Bids must be in before September 16.

★ ★ ★

Arizona Test Underway

Shell Oil Company is drilling an exploratory well in the Boundary Butte area of Apache County, Arizona. Last March, Shell drilled an exploratory well in the same area which for a time flowed gas at a rate between 2 and 3,000,000 cu ft a day. The production was from the Hermosa formation.

What's coming... in your October issue of "Drilling and Producing."

Methods Improvement in Drilling Operations — Wilson J. Bentley, Consultant and Professor of Industrial Engineering, Oklahoma A&M. A 3-part series giving answers to higher drilling costs.

With drilling costs increased, better use of both machine and personnel time is needed by the contractor: intelligently applied "job design" can accomplish this.

Rig minutes are important — waste five of them a tour and you loose almost four rig days a year. Detail studies of crew activities show much lost motion.

Efficiency in moving is vital. Time carelessness can mean the loss of major drilling profits.

Petroleum Geology of Western Canada — F. H. Edmunds, Consultant, member Petroleum Conservation Board and Professor, University of Saskatchewan — complete discussion of productive areas, stratigraphy, structure, including maps, formation charts and cross-sections in this tremendous frontier of active oil and gas developemnt.

Read these and many more articles important to your operations in October "Drilling and Producing."

Houston U. Expands Staff

Dr. Leonard B. Lipson, Senior Research Physicist at Magnolia's Field Research Laboratories, Dallas, has been appointed an Associate Professor of Petroleum Engineering at the University of Houston starting September 1, 1954. Dr. Lipson will assist in the development of the graduate program in Petroleum Engineering and will conduct research in the field of core analysis and well logging.

★ ★ ★

Flame Flood Planned

The in-situ experiments which were to be conducted in the South Belridge field, San Joaquin Valley, California, have been temporarily abandoned by General Petroleum Corporation due to unfavorable conditions encountered.

Two core holes were drilled. One encountered gas and the other had indications of an excessive amount of water.

General Petroleum will move the in-situ testing site one section NE where there are presently 3 existing 700-ft wells. It is planned to plug off the bottom zones of these wells and make water content and permeability tests. If these tests prove satisfactory a 4th well will be drilled to form a quadrangle with the other 3 wells. A 5th well will then be drilled in the center, which will be the injection well. It is expected to require approximately 6 months to complete this preliminary work.

★ ★ ★

Wyoming Wildcat

Mountain Fuel Supply Company has announced the discovery of a new natural gas field at Canyon Creek in southern Sweetwater County, Wyoming. A wildcat well gaged 10,000,000 cu ft of gas from the Mesaverde formation at a depth of 5222 ft. Nearest production is the Sugar Loaf field, 6 miles away.

★ ★ ★

AAODC to Hold Convention

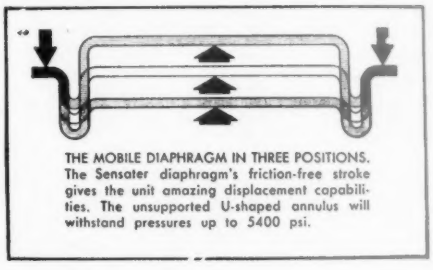
The 14th convention of the American Association of Oilwell Drilling Contractors will be held at the Los Angeles Biltmore Hotel on October 10, 11, 12, and 13. Included in the program are papers on instrumentation, power pump operation, public relations, drilling cost reduction, drilling problems, and safety in addition to a full complement of committee meetings and social activities.

Remarkable new pressure transformer gives you weight-indicator accuracy never before thought possible

The Martin-Decker E-80 SENSATER

with the *MOBILE DIAPHRAGM*

Although the Sensater is a diaphragm-type pressure transformer, it slips in place on the anchor in the same manner as the piston type. Deadline pull on the anchor immediately transmits an accurate signal to the driller's weight-indicator dial.



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The E-80 Sensater is rugged and foolproof. It is designed for years of trouble-free operation and to give you weight accuracy never before thought possible.

Further information about the Sensater can be had by writing to the Martin-Decker Corporation, 3431 Cherry Ave., Long Beach 7, California.

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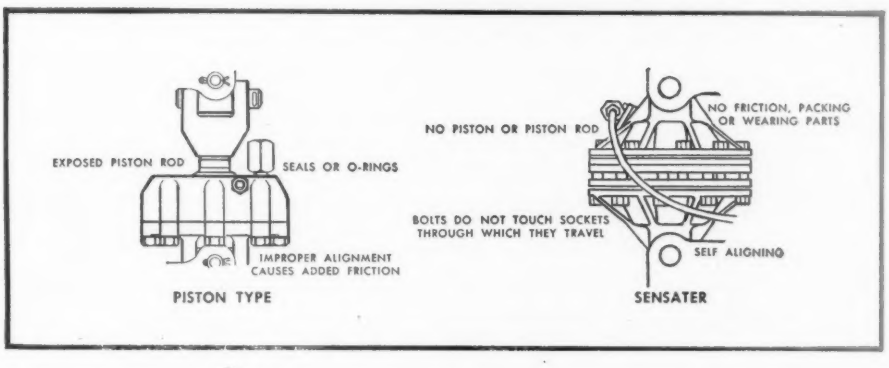
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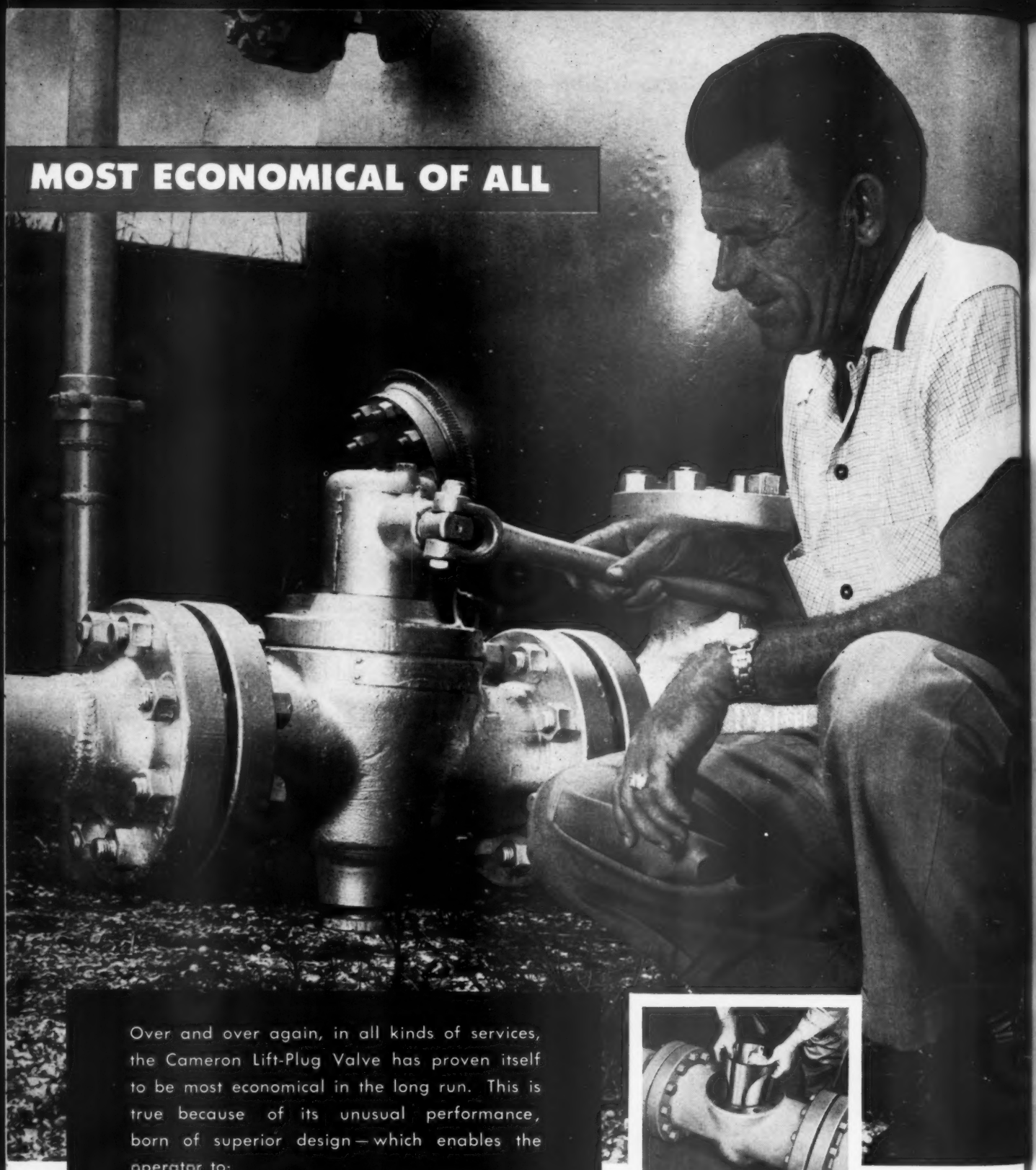

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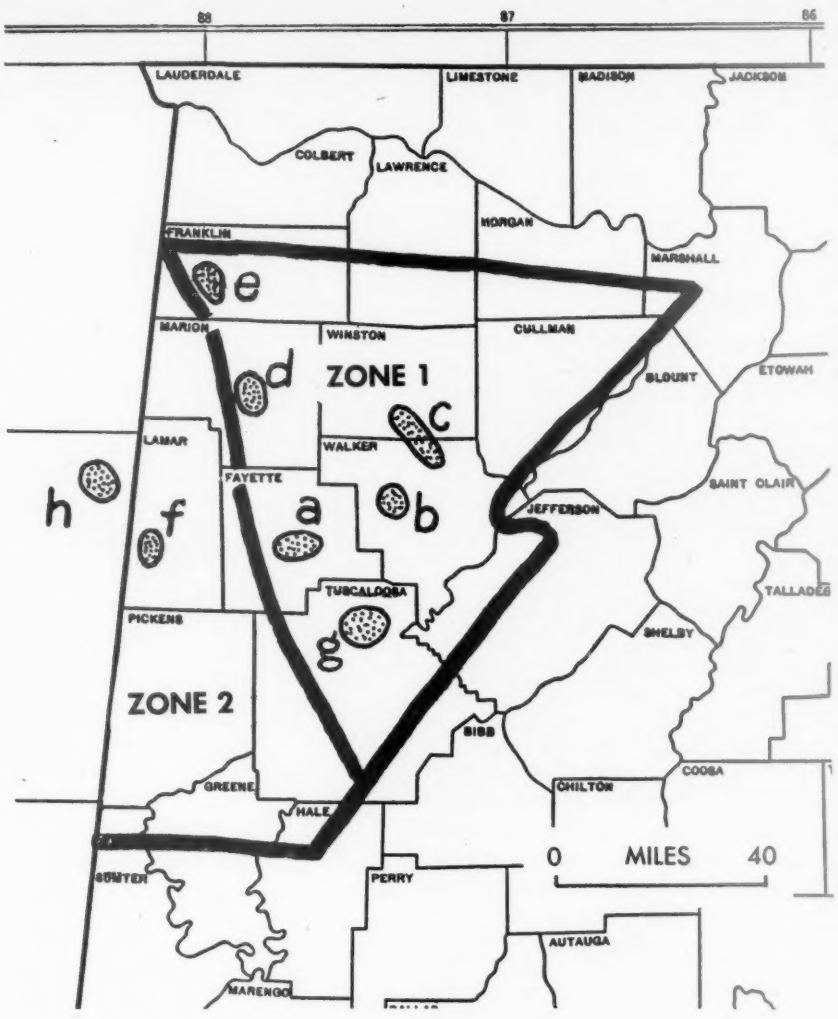

Legend

a—Fayette Gas Field*
b—Jasper Gas Field*
c—Nauvoo Gas Field●
d—Hamilton Gas Field●
*Abandoned

e—Hodges Oil and Gas field
f—Gardner Well*
g—Berry Dome
h—Muldon Field (Miss.)
●Potential

Oil and Gas Possibilities in the Warrior Coal Basin in Alabama

WALTER BRYAN JONES*

IN SPITE of the comparatively large number of wells drilled in the Black Warrior Basin in Alabama, little is known about sub-surface conditions. Until recent years, only drillers' logs were kept and they contributed almost nothing to the knowledge of formations encountered. The very nature of outcrops lends neither satisfaction nor accuracy to surface studies. Good horizons for mapping structures are scarce. Unquestionably many and good structures do exist, some of which are known, and more can be worked out through patient and sound surface study and core drilling.

*State Geologist and Oil and Gas Supervisor, University, Alabama.

Geology

1. Upper Cretaceous. Beds of Ripley, Selma Chalk, Eutaw, and Tuscaloosa formations blanket the western part of the basin. (See map.) It is unlikely that oil or gas will be found in these, for they are not thick enough. However, they do greatly complicate the assessment of values in the underlying paleozoics. Unless some method is devised to overcome this handicap, prospecting in Zone 2 will be mostly "hit or miss."

2. Pennsylvanian. Varying thicknesses of shales, sands and conglomerates outcrop over, and underlie Zone 1. Basal members of the group occupy the northern fringes of the basin and attain a thickness of perhaps 2500 ft in Tuscaloosa County. Gas in the Fayette wells came from two sands near the middle of the series. Where sufficiently covered there is no reason why the sands in the Pennsylvanian should not

EXCLUSIVE

produce both oil and gas.

3. Mississippian. This group comprises the Bangor, Hartselle, Gasper, Bethel, St. Genevieve, and Tuscumbia formations, each with possible petroliferous horizons. Numerous shows of oil and gas have been reported in wells penetrating these beds. Beyond the northern fringe of the basin the Hartselle is asphaltic at the outcrop from Hartselle, in Morgan County westward to the Mississippi line. The Gasper and Bethel formations are asphaltic in Colbert County. Pockets of oil in quarries in the Bangor are common, especially in Morgan and Madison counties. Under cover these formations are expected to be productive. Asphaltic content in the Hartselle and Gasper range up to 15 per cent, showing good porosity.

4. Silurian. The Niagara beds are thought to be too thin to be of very much importance, although shows of both oil and gas were encountered in these beds in the Haleyville well, in Winston County.

5. Ordovician. This series of limestones, dolomites, and some calcareous shales is regarded highly as possible oil and gas horizons. Certainly the Trenton phase is important, since considerable quantities of oil have been produced from it in Kentucky and Tennessee. The Trenton can be reached at comparatively shallow depths anywhere in the basin. It could well be the most favorable horizon in the area. Yet very few wells have tested its possibilities.

6. Cambro-Ordovician. The Knox dolomites, once lightly regarded, is now in the limelight. In the upper Mississippi valley, many wells have been completed in the Knox, and recently an important discovery was made in the formation in northeast Mississippi. Any serious test in the Warrior basin should penetrate the upper 1000 ft of these beds.

Structure

Major feature of the basin is the Cincinnati or Nashville arch which enters the northwestern part of the area and enters Mississippi through Lamar County. It is characterized by low angle folding and is an excellent area for prospecting. Off the eastern edge is the sharply folded and faulted Sequatchie anticline. In between, gentle warps to strongly folded and faulted areas are interspersed in flat-lying beds, pitching gently to the southwestward. The folding is usually perpendicular or parallel to the Appalachian trend. Where these cross each other should give excellent results. The Berry dome (described later) is perhaps the best known structure in the basin. Nearby, folding and faulting are quite pronounced.

FIG. 1. No. 10A, 30 ft from No. 10 well, Fayette gas field, Fayette County, taken August 3, 1927.

Development

a. Fayette gas field. In 1909 a diamond drill hole was put down just southeast of Fayette in search for coal. The well was 475 ft deep, and encountered two sands with shows of oil. Thus encouraged, the Eureka Company was formed and two deep tests were drilled in the vicinity of the diamond drill hole. On December 20, 1901, one of these encountered gas in a sandstone at about 1400 ft, with an estimated flow of 1,600,000 cu ft per day, and closed pressure of 630 psi. The other test had only shows of oil and gas.

The Eureka Company was merged with the Providence Oil and Gas Company, and some 43 wells were drilled between Fayette and Bankston, about 10 miles to the eastward. Six wells in the vicinity of Fayette had gas ranging from 1,000,000 to 4,500,000 cu ft per day. In 1914 a pipe line was contemplated but never built. Anyway, a ready supply of cheap coal imparted no enthusiasm for gas, and many failures put an end to the project. Most of the wells reported shows of oil or gas or both. Drilling ended in 1917.

Best gas was found in the Fayette sand, in the Pennsylvanian at about 1400 ft. It is a soft, white sand of good porosity. About 200 ft deeper, the second sand gave up excellent shows. The discovery test reported a 15-ft sand saturated with oil at 415-430 ft. The record does not show that it was tested.

In examining the wells in 1926 and since, the writer concluded that there was little casing in the holes, permitting water to drown out the sands. Most of the holes are open today, and full of water, a few overflowing. Some still show bubbles of gas while at least 2 make some oil. In 1926 the writer drew a 5-gal sample from the No. 10 well, about half a mile west of the discovery, using an ordinary water tube tied to a plowline. (See Fig. 1.) No. 1 Freeman, 2 miles southwest of Banks-

The Author

Walter Bryan Jones is Alabama's state geologist. He is a graduate of the University of Alabama with an A.B. and an A.M. degree and has a Ph D degree from Johns-Hopkins University. He was employed by the Mexican Eagle Petroleum Corporation in Mexico during the summer of 1920-22 and was also an instructor in geology at the University of North Carolina. He served as assistant state geologist of Alabama from August 1, 1924 till 1927 at which time he was made state geologist, succeeding Dr. Eugene A. Smith. A veteran of World War I and II, Jones has a reserve commission as a Colonel in the Corps of Engineers. Jones is a director of the Alabama Museum of Natural History, a Fellow of the Geological Society of America, a Fellow of A.A.A.S., member of American Institute of Mining and Metallurgical Engineers, a member of American Association of Petroleum Geologists and a member of many other state and national organizations.

FIG. 2. H. L. Cullet's No. 1 A Lewis, near Hamilton, Alabama.

FIG. 3. H. L. Cullet's McCarney-Bannister, near Hamilton.

ton, is another example. With modern drilling technique and conservative measures, the Fayette field might have been strictly commercial, and could have changed the history of the industry in the state. Certainly a saturated sand, at whatever depth, would have been thoroughly tested.

b. Jasper wells. In 1911-12, the Pennsylvania Oil and Gas Company drilled 6 wells near Jasper, known locally as the Shannon wells. Three of the wells encountered gas in the Hartselle, at about 1800 ft. They were shot and measured at 150,000 cu ft per day and were abandoned. Most of the wells had shows of both oil and gas. Years afterward, the writer went to the site to look into a report that one of the wells had erupted oil. It had flowed several barrels of oil into a small branch. The well was overflowing water at the times of the visit, with gas bubbles and an occasional drop of oil. Again there was no inkling as to where either was coming from.

c. Nauvoo gas field. In 1944 Glenn Rose drilled a well near Poplar Springs, in Winston County. It was completed in the Mississippian, acidized and closed in. Estimated flow is 750,000 cu ft per day. Rose then moved to a location near Manchester, in Walker County, and put down his No. 2 well. During drilling, the well was flaring a 20-ft flame of gas. No effort was ever made to complete it and it remains, the state still holding his bond, though Rose has long since left these parts. Rose next moved to an offset to his No. 1, with similar results to No. 2. It, too, awaits completion.

The author spent a day looking over the area and concluded that Rose was drilling on the flanks of an anticline extending from Manchester, northwestward to Poplar Springs. A bit of patient study might achieve some good results there.

In visiting the No. 3 well while it was being drilled, the writer observed oil shows from the bailer, in the Bangor and in the Hartselle. The gas is coming from the latter. The gas is dry, burning without smoke. The oil appeared to be high gravity, green in color, and not unpleasant in odor.

d. Hamilton gas field. During recent years H. L. Cullet began work 3 miles southwest of Hamilton, in Marion County. Having trouble with his No. 1 Lewis, he skidded over and completed his No. 1 A Lewis. Gas was encountered (See Fig. 2.) in the Bethel at 1850 ft, now known as the Lewis sand. The well tested 740,000 cu ft per day, and has been shut in pending further development. Cullet had similar results with his second hole. (See Fig. 3.) There were shows of oil in each test. Cullet is continuing drilling, now working on his No. 2 Lewis.

It has been reported that plans have been completed for a pipe line to supply gas to Hamilton and other nearby towns. When that has been accomplished, the Hamilton field will become a reality. The No. 1 McCarney-Bannister is a stepout, while the No. 2 Lewis is an offset. Thus little is yet known about the structure or its extent. It is believed to be on the eastern flank of the Nashville arch.

The sand is rather light. It is thought that oil-frac might be used to step up the capacity considerably. So far, that method has not been used anywhere in the state. The gas is dry.

e. Hodges gas field. During the past two years James L. Duffy, Jack Harrington and associates have been drilling near Hodges, in Franklin County. The No. 1 Bedford, an offset to a well drilled many years ago and having good shows of oil, encountered a fine show of oil at 998-1030 ft. Gas was struck at 1330-1352 ft, with shut-in pressure of 400 psi in the Lewis sand. The oil show was in the Hartselle, and again oil-frac might make the difference. The well is shut in at present.

An offset, the No. 2 Bedford, encountered gas in the Bethel, was cased off and drilling is continuing with the Trenton and Knox in view. At the time this is being written, the well is drilling ahead at 2935 ft. The Knox should be reached at about 3700 ft. The productive horizon is about 400 ft from the top.

Plans are being made to pipe the gas to nearby communities. It is expected that this will become a commercial gas field, with the added and

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strong possibility of oil production.

f. No. 1 Gardner. Some 7 miles west of Vernon, Lamar County, Woodward drilled No. 1 Gardner, some 20 years ago. A strong show of oil, 42 gravity, was encountered in the Mississippian. At the time the author visited the well, it was making ½ bbl per day, in open hole, without swabbing. He expressed the belief then that the well could have been nursed into a producer. The operator decided to shoot the sand, and the shot broke through into a heavy flow of salt water. That was that.

Because of the proximity of salt water to the oil sand, it is likely that the well was located on the flank of the structure. The area is covered by a thick blanket of cretaceous sediments, and is difficult to work by any method now known, except core-drilling, which would be quite expensive. Someday some one will discover the secret hiding place. That grade of oil is worth the cost of finding.

g. Berry dome. Any account of the Warrior basin would be incomplete without a discussion of the Berry (Friedman) dome. It is a tremendous structure some 12 miles in diameter and with a closure of more than 200 ft. There is a fault on its northwest flank and perhaps others exist in the general region. It is in Tuscaloosa County, and is actually nearer Windham Springs than Berry. Observed dips on its sides range from 2 to 6 deg. The late Sam Friedman of Tuscaloosa drilled a hole on top of the dome, reaching a depth of 2950 ft, abandoning the project on May 22, 1921. A strong show of gas was encountered in the Pennsylvanian at 2330-2340 ft. Other gas and oil shows were reported. It is thought that the well ended in the Bangor. A 7000-ft hole there would be interesting to watch.

h. Muldon gas-distillate field (Mississippi). In 1951 an abandoned prospect (the No. 1 Sanders) near Muldon, Monroe County, Mississippi, was reworked and completed as a producer of gas-distillate. Initial tests were 7,500,00 cu ft of gas, gas-condensate ratio 100,000 to 1. The producing horizon appears to be the Hartselle. Other wells have been completed in the field, which gives rise to hopes that discoveries will follow in adjacent parts of Alabama. The field is probably on the Nashville arch. Deeper sands remain to be tested.

Addenda

A few scattered projects are of special interest. One is a series of 4 wells drilled in 1911-12 near Haleyville and Double Springs in Winston County, by the Woodward Oil and Gas Company. The No. 1 Haleyville had a heavy show of gas, estimated at 40,000 cu ft per day, at 2920-2960 ft. A study of the driller's log indicated that the show was in the Knox. Drilling continued to 2980 ft, where a heavy flow of salt water was encountered. The water was later shut off and the well shot with 160 qt of nitroglycerine, greatly increasing the flow of gas. Later the well was abandoned. Two offset wells missed the gas sand. No shows were reported in the Double Springs well.

The No. 1 Hankins, in the eastern part of Lamar County, had excellent shows of oil in the Hartselle sand. The writer tested cuttings from the hole and saw a bleeding core. Still the sand would not give up its oil. Finally the sand was shot, with negative results. The present operator, Paul Buchanan of Birmingham, is contemplating the use of oil-frac to try for production. The condition of the hole following the shot poses a difficult question as to whether or not oil-frac would do any good. A caliper survey might determine the possibilities.

Recently, Duffy and Harrington began their No. 1 Shepard, an offset to the old No. 1 Freeman near Bankston, in Fayette County. The well had a fine show of gas at 3160-3180 ft. Casing was perforated at 3160-3174 ft, encountered water trouble, squeezed off, and reperforated. Tests were inconclusive. Another gas sand at 2000 ft was also tested. Drilling continued to the present depth of 3513 ft. Pipe is set at 3233 ft. If production is not reached at greater depths, the operators plan to rework the well in an effort to bring in one of the upper sands. The writer believes the difficulties to be mechanical and that the chances of success are good.

Conclusions

There appears to be no question about the existence of structures in the Warrior basin, underlain by a goodly number of possible petroliferous horizons, all within comparatively easy reach of the drill. To date most of the formations have been tight and reluctant to give up their oil and gas in sufficient quantity to be commercially feasible. Use of oil-frac is indicated for the sands, and acid for the limestones.

Most of the wells have been too shallow to test the best sands and were drilled without regard to structure. Likewise very few of the projects were adequately financed. A properly cased well was non-existent until the state passed its conservation statutes. Such slip-shod methods defied discovery and hurt the chances for production in the basin. Shallow sands enticed small pocket books. Well financed projects, with the employment of the best methods and techniques, should pay off.

* * *

Mississippi's Hinds County Oil Play Increases as Majors Step In

The discovery of oil in Hinds County, Mississippi, has set off an oil drilling boom in the west central part of the state. Major companies are reported to be paying bonuses as high as $250 and $300 an acre for tracts of land in the immediate vicinity of the discovery.

Larco Drilling Company opened the area with its No. 1 Mrs. Lettie McAlpin. Well is about 12 miles of Jackson near the town of Bolton. Well is now shut in waiting erection of tankage. On a 24-hour test the well flowed 274 bbl of 38 deg oil and 530,000 cu ft of gas from perforations between 9920 and 9940 ft in the Paluxy. Well is said to have 100 ft of pay.

Estimates are that if the well were allowed to flow it would make 400 to 500 bbl a day.

Larco, owned by the I. P. "Ike" La Rue interests, drilled the well on a 60-acre tract that was part of a 1500-acre farmout deal made with Gulf Refining Company. Gulf is reported to receive 50 per cent of the net profits from any production.

Larco company engineers are reported to be surveying the block to locate additional tests. Sun Oil Company has staked No. 1 Lancaster-McAlpin for a south offset. Magnolia Petroleum Company has a lease north of discovery well. Atlantic Refining Company, The Texas Company, Gulf, and Tide Water Associated Oil Company have acreage under lease near discovery.

Geologists have long felt the lower Cretaceous in Mississippi was a favorable production zone but until now oil in the Cretaceous has been found only in the southeastern part of the state.

Another discovery in Hinds County that has aroused interest in west central Mississippi is the Walter E. Sistrunk No. 1 H. T. Shuff Unit. Well is on the Oakley salt dome about eight miles south and a little west of the Bolton discovery. Drillstem tests in the Wilcox sand has recovered oil shows from 2450 to 2605 ft. Best test is reported to have been from 2491 to 2497 ft which recovered 260 ft of gas and 100 ft of 37.9 deg oil.

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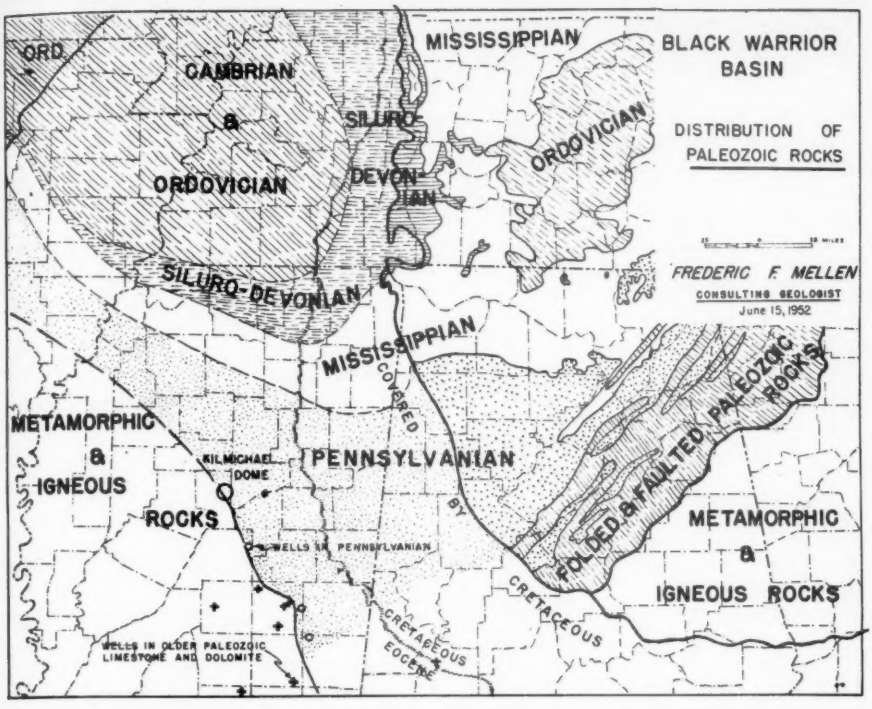
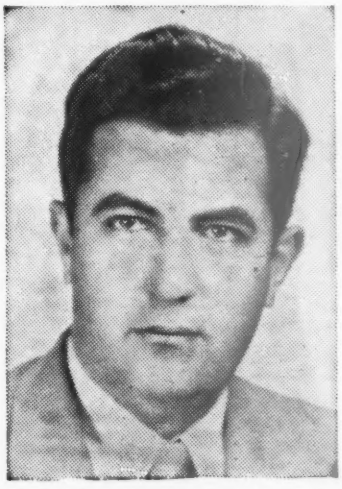


Map of Mississippi's and Alabama's Black Warrior Basin showing the distribution of Paleozoic rocks.

The Author



Frederic F. Mellen is a consulting geologist in Jackson, Mississippi. Before entering consulating work Mellen worked with the TVA, the Works Projects Administration, the Agricultural Adjustment Administration, and the Mississippi Geological Survey. He is best known for finding and mapping the surface structure of the Tinsley Dome in Yazoo County, Mississippi, on which was found the first commercial oil production in Mississippi in 1939. He is a graduate of Mississippi State College with a B.S. in geology and has a M.S. in geology from the University of Mississippi.

Recent Black Warrior Basin Developments

FREDERIC F. MELLEN

RECENT developments in the Black Warrior Basin have answered the objections of many geologists to the area. One of the chief arguments has been that there is a scarcity of reservoirs. The deep wells that have been drilled since the discovery of Muldon gas-condensate field in 1952 have revealed large potential oil and gas reservoirs not only in the Chester sands but in the deeper Devonian cherts and in the Knox dolomite group. Another important objection to the area has been the cost of drilling. There has been a steady improvement in drilling techniques so that the costs of wells in the area are being consistently reduced.

In 1939, Adams Oil and Gas Company drilled its No. 1 Lewellen in Lafayette County, Mississippi, to a depth of 4185 ft. The hole was cut with conventional rock bits through the soft Tertiary and Cretaceous sediments, into the Paleozoic Pennsylvanian rocks at 1845 ft, through lower quartzitic Pennsylvanian sandstones, a short Mississippian section, through approximately 1000 ft of Devonian and Silurian cherts and through hard Ordovician sandstone and into the softer limestone and dolomite of the Ordovician and Cambrian. The Knox dolomite was encountered at a depth of 4050. Elapsed time of 130 days was required to drill to the total depth of 4185, or 2340 ft into the Palezoic.

The bit record shows that 424 bits were used. In the 1332 ft of chert and cherty limestone between the depths of 2442 and 3774 ft, 363 bits were used, an average of 3.67 ft per bit.

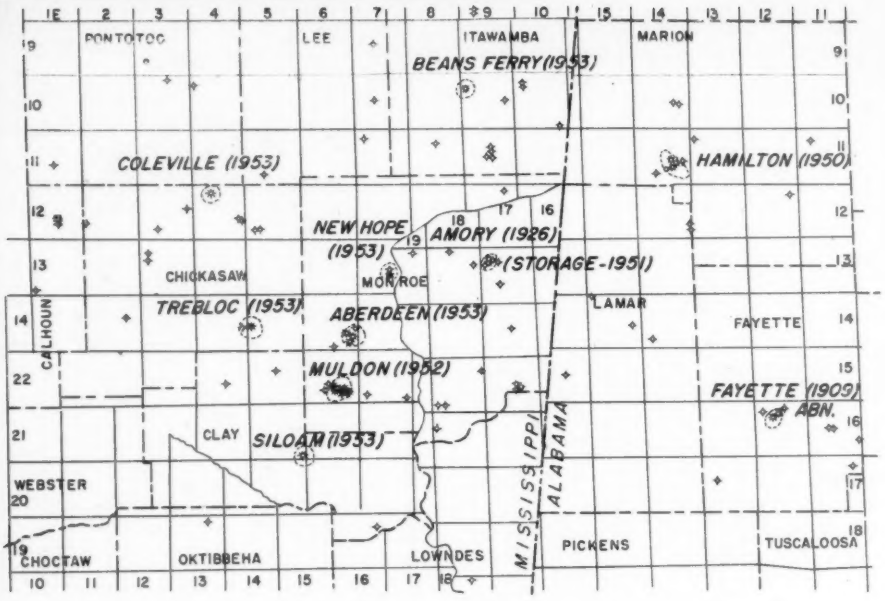
In 1953, L. E. Salmon's No. 1 Patterson in Pontotoc County, about 11 miles southeast of the Lewellen well was drilled in 88 days with a total of 84 rock bits to a total depth of 5903, or a total of 4361 ft in the Paleozoic. The section penetrated was essentially the same as the one penetrated in the Lewellen well except that there was added section of abrasive lower Pennsylvanian sand; however, the great improvement in penetration rate was through the Devonian and Silurian cherts where the new tungsten carbide insert bits were used and averaged over 100 ft per bit.

EXCLUSIVE

At the present time, Honolulu Oil Coporation, on its No. 2 Davis, has improved materially on the record established by Salmon. In 60 days this well had penetrated all of the section of the Patterson and the Lewellen wells, had averaged 100 ft per day and had achieved a record of well over 100 ft per bit through the Devonian and Silurian cherts.

Thus, the new tungsten carbide bits have not only rendered the area drillable, but have helped reduce the cost of drilling in the area to a point that the cost of a 6000-ft Knox dolomite test is comparable to the cost of an 11,000-ft Tuscaloosa test in South Mississippi. The cost of diamond coring for penetration alone has proved to be too expensive.

Due to the complex stratigraphic and structural patterns of the area, the drilling and testing procedures will vary. Cable tool rigs are being used on



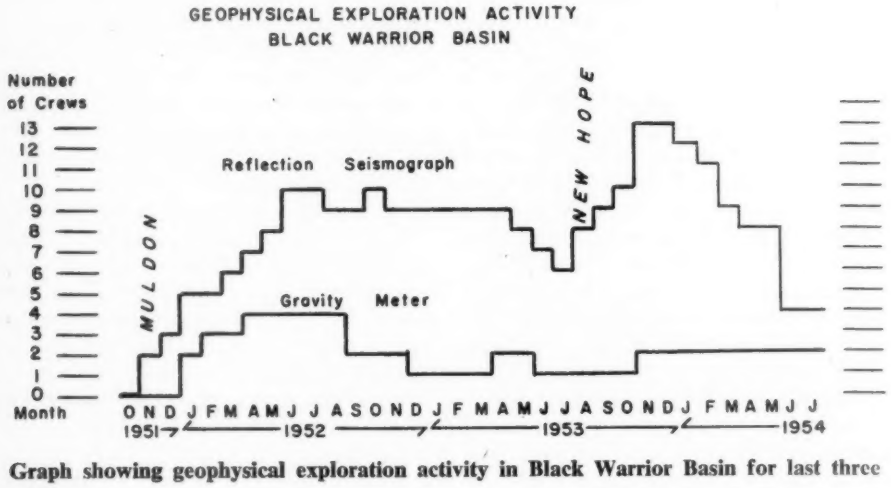
Plat showing sites of gas and condensate wells discovered in the Black Warrior Basin.

TABLE 1. Recent discoveries — Black Warrior Basin.

Field	Completion date	Operator	Well	County	Horizon	Production
Hamilton	2/21/50	H. L. Cullet	1A—Lewis	Marion, Ala.	Chester—Lewis sand	Dry gas
Muldon	2/18/52	Union Prod.	1—Sanders	Monroe, Miss.	Chester—Carter & Sanders sds.	Gas-cond.
Aberdeen	1/12/53	Shell	1—Harrington	Monroe, Miss.	Chester—Sanders sand	Dry gas
Trebloc	3/16/53	Carter	1—Baskin	Chickasaw, Miss.	Chester—Carter sand	Gas-cond.
Colevill e	4/ 1/53	Vaughe	1—U. S. A.	Chickasaw, Miss.	Chester—Evans sand	Dry gas
Siloam	7/22/53	Carter	1—McFadden	Clay, Miss.	Chester—Millerella sand	Gas-cond.
New Hope	10/26/53	Magnolia	1A—Snow	Monroe, Miss.	Knox dolomite	Oil (35°)
Beans Ferry	10/28/53	J. F. Crow	1—Summers	Itawamba, Miss.	Chester—Lewis & Evans sands	Dry gas

shallower wells in the northeast corner of Mississippi and North Alabama, where the Paleozoic rocks crop out or are near the surface. Farther Southwest, where the Cretaceous and Tertiary overburden is thicker, rotary drilling is necessary. Combination drilling has not been used to any important degree.

A careful study of the bit records in the Black Warrior Basin will lead to a phenominal reduction in the time and costs of drilling. The examination of the bit record and the lithology of one 4200-ft Knox dolomite test drilled in 1953 in 33 days with 52 rock bits indicated a wasteage of at least a dozen hard formation rock bits with a corresponding wasteage of time, fuel, and other items of cost. The same operator would probably reduce his time to 27 or 28 days on another well in that



Graph showing geophysical exploration activity in Black Warrior Basin for last three years.

TABLE 2. Approximate acreage under lease by major companies in Black Warrior Basin.

	Mississippi	Alabama
Arkansas Fuel	0	44,000
The California Company	40,000	56,000
Carter	267,000	171,000
Cities Service	80,000	20,000
Continental	0	92,000
Gulf	134,000	23,000
Honolulu	107,000	28,000
Magnolia	264,000	286,000
Ohio	15,000	0
Pure	100,000	25,000
Seaboard	265,000	0
Shell	185,000	274,000
Stanolind	67,000	0
Sun	100,000	75,000
The Texas Company	210,000	40,000
Union Producing Company	225,000	75,000
Totals	2,059,000	1,109,000

Also represented with blocks and/or checkerboard acreage: Ashland, Atlantic, Lion, Midstates, Pan American, Sinclair, Sohio, Southern Natural Gas, Sunray, United Carbon, Pacific Western. — October, 1953.

vicinity.

A number of the operating companies have formed a group for the study of reservoirs through the pooling of information on drill stem tests and analyses of salt water.

About a dozen wells in the Monroe County area have shown thick porous pulverulent chert in the Devonian. The thickness of this reservoir is commonly several hundred feet. The Devonian has carried numerous shows of oil and gas in cuttings and cores and on drill stem tests. A recent pumping test in the porous Devonian chert yielded gas-cut salt water at a rate of 470 bbl per day. Good flowing pressures have been recorded on drill stem tests in this horizon.

The Knox dolomite, too, contains several reservoir horizons that are worthy objectives for deeper drilling in the Black Warrior Basin. The first oil production from the Magnolia No. 1-A J. B. Snow in Monroe County was from a depth of approximately 170 ft from the top of the Knox dolomite. Other porous and permeable zones have been found in various counties.

The Honolulu No. 2 Davis has recently recorded by electric log and microlog over 100 ft of porous and permeable dolomite carrying gassy salt water approximately 800 ft below the top of the Knox. In Monroe County, the Magnolia No. 1 Pierce, the North offset to No. 1-A Snow, encountered porous and permeable dolomite about 2600 ft below the top of the Knox.

There is certainly a great need for deeper drilling in the Black Warrior Basin to determine more about the reservoir possibilities in the Knox dolomite and in the possible sands below the Knox. The nearest deep control of this sort is in Giles County ,Tennessee, about 100 miles northeast of our main area of interest, where the California Company's No. 1 Beeler encountered granitic rock below 4920 ft of the

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Knox dolomite group. An arkosic detritus approximately 125 ft thick was present above the granite in that well. Slight oil, asphalt, and gas shows were noted at various intervals throughout the Knox section.

Coincident to the drilling of several deep and expensive test wells, and to a probable temporary decline in discovery rate, the revival of interest in central and southern Mississippi has caused a severe decrease in Black Warrior Basin activity. This is shown on the graph of geophysical activity. The development of the important Eutaw and Tuscaloosa gas-condensate reserves at Maxie-Pistol Ridge, and of the still more important Comanchean oil sands at Soso and, currently, at Bolton, has focused attention farther south. This shift in interest has been fully justified.

Most of us who watch Mississippi's Paleozoic development, however, feel that the ultimate results of the current Comanchean oil boom in central Mississippi will benefit the Black Warrior Basin, that Mississippi is becoming increasingly important as a petroliferous province, and that the geological and geophysical developments of the last two and one-half years have been, on the whole, encouraging.

The Black Warrior Basin can expect to have a material increase in activity in the relatively near future. As soon as marketing of gas and condensate from Muldon, Aberdeen, Trebloc, and other fields has begun there will be an increased incentive for development. All of the essential conditions for important and economically profitable deposits of oil and gas are present. Reservoirs have been established in Cambrian, Ordovician, Devonian, Mississippian, and Pennsylvanian rocks. The metamorphism of these rocks has not been intense in the area of maximum drilling activity.

Drilling and geophysical exploration have indicated structures of major size and numerous smaller structures. There are faults present in the area which, in some cases, may have displacements of 1000 ft or much more. Stratigraphic traps are present, such as the up-dip wedge-out of various Chester sands and the up-dip truncation of the porous Devonian chert. Source rocks are certainly evidenced by the numerous shows of oil and gas throughout the rocks of every system. Shales and limestones provide a copious cover for the fungacious and vagrant molecules of gas and oil. The Black Warrior Basin should in time live up to the expectations of the dozens of oil companies and scores of independents who have invested extensively in leases, minerals, geophysical exploration, and drilling. * * *

Union Producing Begins Black Warrior Gas Production

DISCOVERY of the Muldon field in Monroe County, Mississippi, by the successful completion of the Union Producing Company No. 1 Sanders, marked the beginning of an intense leasing and exploration program in the Black Warrior Basin by many of the major oil companies. Wildcatting during the past two and one-half years has resulted in the discovery of six gas fields (all producing from the Chester) and one oil field which encountered saturation in porous Ordovician dolomite.

During the early part of 1941, the Carter Oil Company assembled several lease blocks in Monroe, Clay, and Chickasaw counties, Mississippi. These blocks were taken in areas which were mapped by Carter's reflection seismograph as structurally favorable.

Between July and November, 1941, the Carter Oil Company No. 1 Sanders was drilled in the Muldon area. Well was abandoned as a dry hole at a total depth of 6059 ft in the upper part of the Iowan. No drillstem or production tests were made of the well.

Some time after Carter plugged the No. 1 Sanders, it was noted that a very small volume of gas was escaping from the well. It was apparently regarded with only passing interest. J. T. Sanders, however, on whose land the well was located, together with several other local persons re-assembled the old Carter lease block during 1951.

The Northeast Mississippi Oil Company, a small company owned principally by Howard A. Nason, Malcolm McCaskill, and Charles McCamic, was formed for the purpose of acquiring the Muldon lease block from Sanders et al, and cleaning out the old No. 1 Sanders well.

Operations were begun on October 19, 1951, with a small rotary workover rig. On November 6, while cleaning the old hole at 2950 ft, the well blew out making an unestimated amount of gas. After four days, with the help of a special crew, the operators successfully installed a master gate on the surface casing and directed the gas flow through a flare-line to a burning pit.

The Union Producing Company assumed operation of the well after purchasing a partial interest in the well and lease block from the Northeast Mississippi Oil Company.

A large rotary rig was immediately moved on the well, and 40 days after it blew in, Union was successful in partially killing the well with heavy mud so that it could safely be shut-in. It was then necessary to clean out the 2950 ft of drill pipe which had been dropped in the hole. After 54 days of continuous fishing operations, 24 days of which were spent washing and cutting, all but approximately 260 ft of the drill pipe was recovered.

Fishing operations were completed with the top of the remaining drill pipe at 5232 ft. Five and one-half inch casing was cemented with 2270 sacks at 5186 ft at a point 70 ft above the Carter sand (Mississippian-Chester). Well was brought into production February 17, 1952, producing gas from the open hole below 5186 ft. The open flow potential of the No. 1 Sanders was calculated at 35,000,000 cu ft of gas per day.

Development of the field is now complete with 8 gas wells and 3 dry holes having been drilled. The gas wells are completed at a depth of about 5500 ft and 4 of the wells have been sand-oil fractured. Tests indicate this treatment is successful.

The productive portion of the Muldon field structure is anticlinal and is bounded on the north and southwest by normal faults which dip north and southwest respectively. Displacement on these faults is several hundred feet and their dip averages from 65 to 70 deg. Within the field the Chester beds dip south at the rate of 125 ft per mile. Production is limited on the south and southeast by a gas/water contact in the vicinity of 5275 ft.

The Sanders zone is the principal sand in the Chester gas pool. Wherever this sand has been encountered above the gas/water contact, it has been found productive. It is approximately 100 ft thick and the top 20 or 30 ft are non-permeable and shaley in several wells.

Gas in the Chester reservoir is sweet and is composed of about 85 per cent methane. The remaining 15 per cent consists of ethane's plus and only traces of carbon dioxide and nitrogen are present. The condensate appears to vary somewhat from well to well but an analysis of the condensate from the No. 1 Sanders well shows this liquid is 64.4 API gravity, sweet and water-clear. Preliminary tests indicate a gas-condensate ratio of approximately 80,000:1. Bottom hole pressures are considered normal for the reservoir depth.

Numerous shows of oil have been observed in cores and cuttings from every well in the Pottsville sands. Extensive testing efforts have not revealed the existence of any producible oil and at this writing it is not known if improved drilling and testing methods might establish Pottsville oil production at Muldon.

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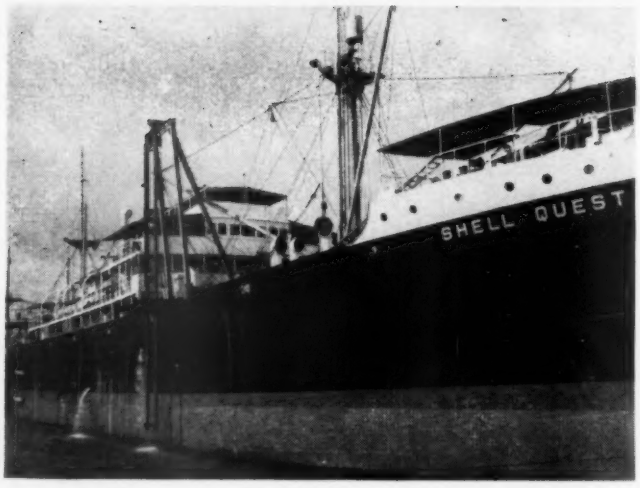

In 1952 Shell acquired a concession to carry out a search for oil beneath the waters of the Persian Gulf. Exploration will shortly be facilitated by a specially equipped depot ship, the "Shell Quest."

Commander J. Y. Cousteau, famous under-water "explorer" has been commissioned by the D'Arcy Exploration Company, the prospecting subsidiary of Anglo-Iranian Oil Company, to investigate the waters off Abu Dhabi in the Persian Gulf.

Oil Exploration in the Persian Gulf

Shell group now actively surveying concession off shore of Qatar obtained in 1952

V. S. SWAMINATHAN

A COMPANY of the Royal Dutch-Shell Group acquired in 1953 a concession to carry out a search for oil beneath the waters of the Persian Gulf from the ruler of Qatar, His Excellency Sheikh Ali bin Abdulla bin Qasim al Thani.

Submarine exploration, employing both gravimetric and seismic methods, is now in full swing. With gravimetric survey, a launch carries a remote control gravity meter, fitted into a waterproof steel housing, which is lowered over the stern to take measurements of the slight variations in the force of gravity on the sea bed caused by the underlying lithological formations of differing densities.

In the case of the seismic survey, two launches are used — a "shooting boat" which fires charges at regular intervals and an "instrument boat" towing a series of seismometers on floats which pick up the vibration waves from the explosions when they are reflected back from the different hard-rock layers below the surface. These reflections are then recorded photographically on an instrument.

In order that the exact position of the survey launches can be known when readings are taken or charges fired, a Decca Navigator installation is used, whereby the entire exploration area is covered by a "lattice" of short waves sent out from 3 stations set up on land, 1 on the tiny island of Halul, 60 miles offshore and the others, together with a monitor station, on the mainland of the peninsula.

The specially converted 4000-ton ship Shell Quest is now anchored off Doha, the capital of Qatar, and is serving as a maintenance depot for the several small craft engaged in the operations, as well as for the work of constructing a movable drilling foundation.

Although this is a marine concession, some shore installations are essential, and Shell is developing two sites on the mainland — a residential area to the north and an industrial area to the south of Doha.

The Qatar peninsula itself is a barren desert Sheikhdom, some 100 miles long and 80 miles across the widest point, jutting into the Gulf from the Arabian mainland. At the capital much development work is under way by the ruler's government. Schools have been established and a small temporary hospital built, while a beginning has been made on a substantial 100-bed hospital. Electric power is being installed and work is well advanced on the building of roads and the provision of a piped water supply to be fed partly from wells some 20 miles away inland and in part from a sea-water distillation plant. All these activities stem directly from the royalty and revenue derived by the ruler from the operations of Petroleum Development (Qatar) Ltd., an affiliate of Iraq Petroleum, at Dukhan. This field on the western side of the peninsula accounts for over 100,000 bbl per day of 39 deg API crude.

Anglo-Iranion's exploration of the two marine areas off the Trucial Coast in the Persian Gulf started in the early part of 1954. Commander J. Y. Cousteau, an under-water explorer, was commissioned by the D'Arcy Exploration Company, Anglo-Iranian's prospecting subsidiary, to investigate the waters off Abu Dhabi on the Persian Gulf where it holds a concession over 12,000 sq miles for a period of 65 years. Commander Cousteau with his team of divers operating from the research vessel "Calypso" will scan the sea bed in waters up to 250 ft in depth and bring to the surface specimens for checking by the company geologist on board the ship. When the result of the survey is assessed, structures worthy of detailed examination will be identified with a view to test drilling. * * *

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Performances like this moved Jess Hill, truck pusher for Heard & Heard, to observe, "We standardized on Caterpillar-built Tractors because they are the best made, in my estimation."

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Production With Plunger Lift

Free falling plunger actuated by formation or injected gas may improve lift efficiency and prolong flowing life of properly selected wells

GERALD R. BOND

SUCH problems as (1) low volumetric efficiencies with downwell pumps caused by the presence of gas, (2) accumulation of tubing paraffin; (3) wells that periodically die because of bottom hole water accumulation, and (4) weak flowing wells resulting from gas slippage, are being solved in a number of cases by the use of the plunger lift method.

This gas lift method of producing is by no means new, but is rapidly entrenching itself, not only in the United States but also in other oil producing countries. Theory of operation is quite simple. Many years of research, field operations, and subsequent development have brought about a simplified, low cost, trouble-free method of producing where proper conditions prevail.

This report is primarily based on operations in the Newcastle, Wyoming, area. Installations in this area range from 3600 to 6400 ft deep. All are in 2 or 2½-in. tubing and are operating on formation gas without supplemental gas from outside sources. It appears likely, however, that in the near future gas may be available for injection in wells that lack sufficient formation gas.

Theory of Plunger Lift

The plunger lift method is based on the sound theory that a plunger or piston between an oil and gas column will reduce the amount of slippage of gas through the oil, enabling the well to more effectively use its lifting potential, i.e., its natural power of gas expansion, to lift the all-important fluid from the well.

In order to attain the desired effect, it is necessary to control the travel of the plunger within the tubing string. There must be: (a) valve in the plunger to permit it to fall through the fluid on its descent to the bottom stop, (b) a means of closing this valve at the stop, and (c) a means of opening this valve at the surface. The plunger must be

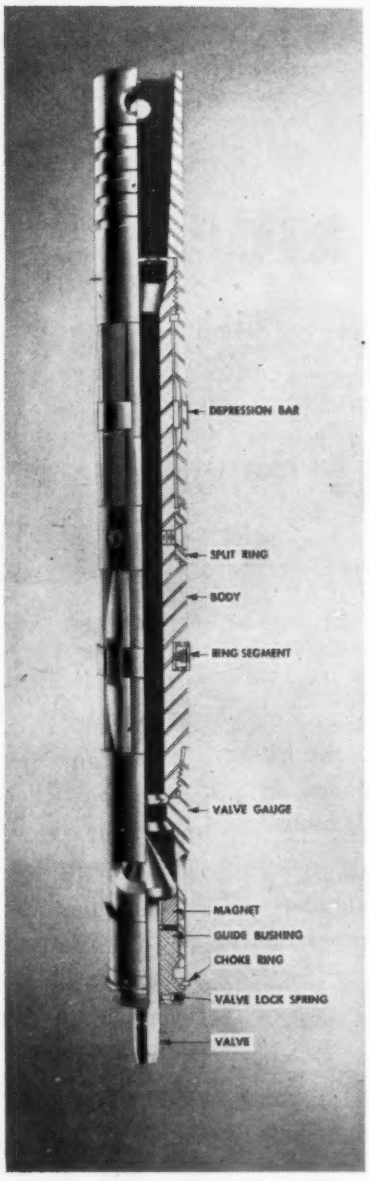

FIG. 1. Key to the operation of plunger lift is this expanding type plunger, which permits operation of the system without the necessity of special tubing. Spring mounted ring segments and vertical depression bars provide an effective seal by maintaining contact with inner wall of tubing.

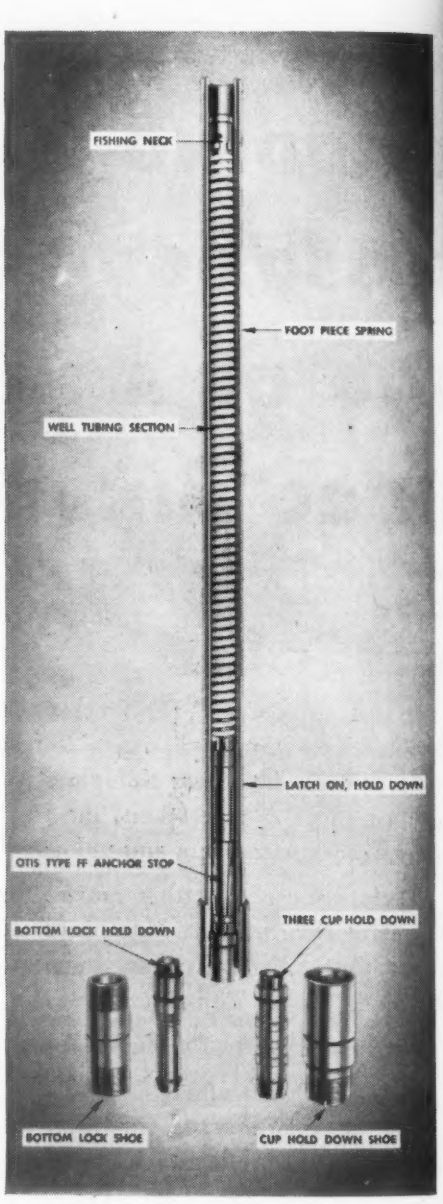

FIG. 2. Sectionalized view of downwell removable footpiece. The assembly consists of a combination Otis-type fishing neck and footpiece seat which the plunger strikes to close its valve; a compression type spring which absorbs impact of plunger in final stage of descent, and a bottom adapter.

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Hollow Sucker Rod

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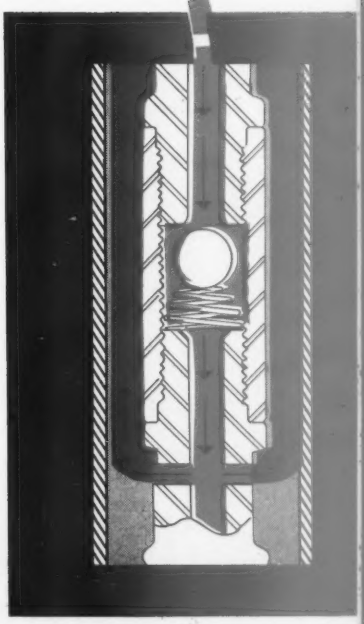
Axelson, with its tremendous background (over 62 years) in the manufacture of petroleum pumping equipment, is providing operators with the *first* hollow sucker rod with ends *forged* integral with the body of the rod—no weldments. HOL-O-ROD rods are forged, heat treated, descaled and processed with the same care as the well known Axelson sucker rods. When used together in a well installation, they form a quality string that aids production and cuts operating costs.



Schematic drawing illustrates flow pattern of injected fluid through hollow rod and check valve, out pony rod perforations and into the production annulus.

Send for folder #5402-P giving complete technical data including sizes, chemical and physical properties; load factors.

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constructed so that it can run in standard tubing and thereby eliminate special tubing or the removal of tubing already in the well. Likewise, this plunger must offer an effective seal within the tubing as it ascends with its load of fluid.

How Plunger Is Controlled

Control of the plunger is accomplished at the surface by the opening and closing of a diaphragm valve in the flowline. When the flowline is opened the plunger begins its ascent to the surface, where it is stopped within a bumper housing assembly. As the plunger is stopped, two actions occur: (1) the plunger valve is pushed in an open position by a "stinger," and (2) valve action caused by the plunger's presence releases pressure from the diaphragm valve and closes the flowline. With the flowline closed and the plunger valve open, the plunger is free to fall by gravity down through the well gas and fluid column and finally is brought to rest on the stop at its setting within the tubing. As the plunger contacts the stop, (which absorbs the shock) the plunger valve closes mechanically and the plunger stands ready for the flowline to be reopened. The stop may be installed without pulling tubing. It is held in position by either an API hold down for locking into a corresponding type pump shoe, an Otis "latch on" hold down which locks over the fishing neck of a Type FF Pack-Off Anchor stop, or special devices to lock in any tubing string.

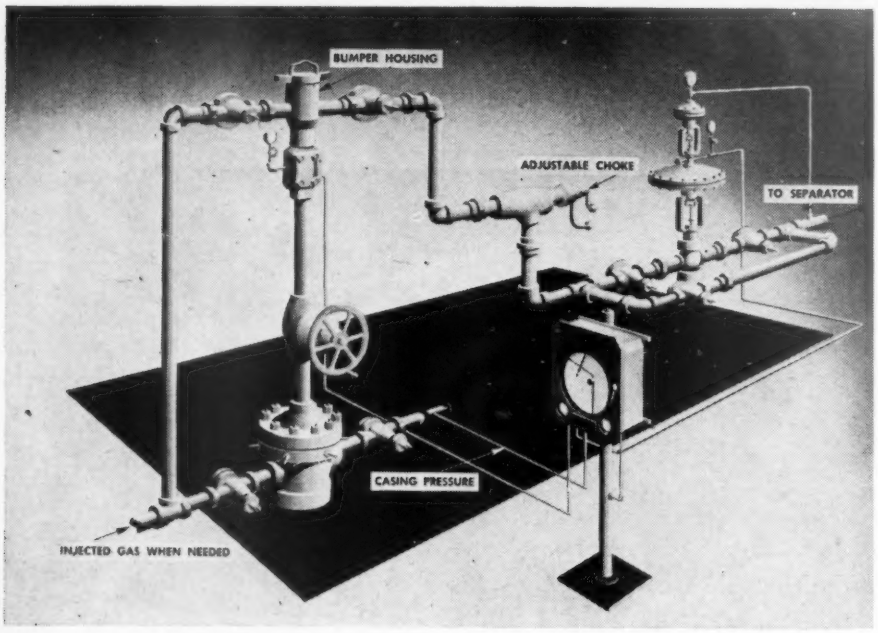


FIG. 3. Surface installation of Ideal plunger lift with Taylor Type C-1 cycle controller.

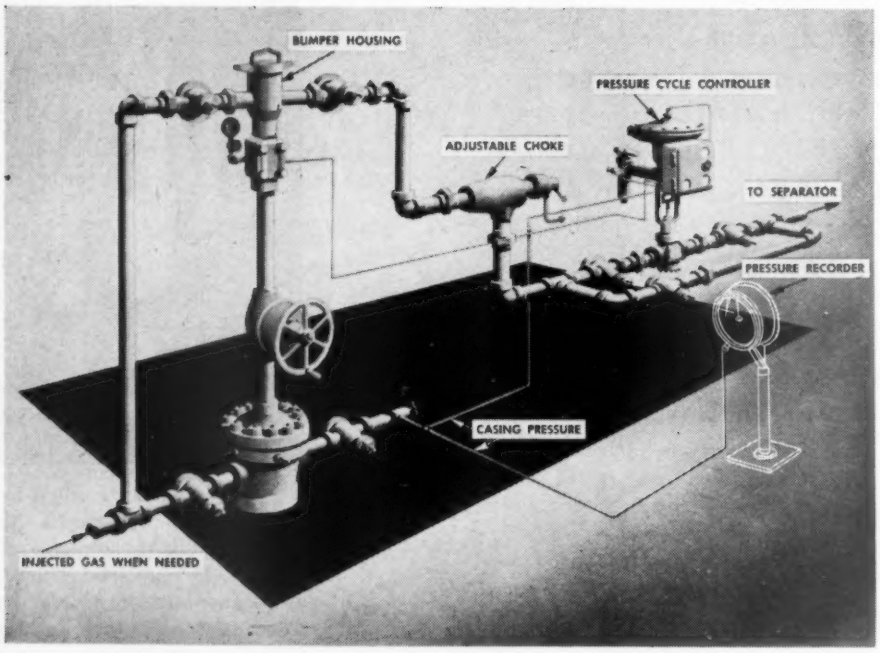


FIG. 4. Installation with Fisher Type 4107U cycle controller and motor valve unit.

The Author

G. R. Bond is sales representative for The National Supply Company in Denver, Colorado. A graduate in petroleum engineering from Colorado School of Mines, Bond joined National Supply in 1950. He spent three and a half years in Casper, Wyoming, before being transferred to his present post in 1954.

Opening of the flowline is accomplished by the increase of either casing or tubing pressure. The standard installation, involving no packer, depends upon casing pressure increase to open the diaphragm valve. When a packer is used, a tubing pressure increase permits the opening of the valve. The actual opening is by means of an instrument which allows a supply gas to be directed to the diaphragm valve when casing or tubing pressure reaches the predetermined pressure set on the instrument.

The 20-lb supply gas for instrument operation can be obtained by reducing casing pressure from the wellhead outlet, or if a packer is used, the supply can be obtained from the flowline by means of a simple scrubber and sufficient trap pressure.

Summarizing equipment operation:

(1) The flowline is opened when the casing or tubing pressure reaches the predetermined setting on the instrument;

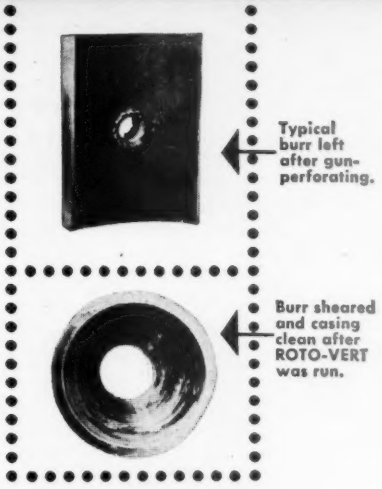
(2) The plunger travels the length of tubing between the bottom and surface stops;

(3) When the plunger enters the surface housing assembly, the flowline closes, the plunger valve opens, and the plunger descends for another load.

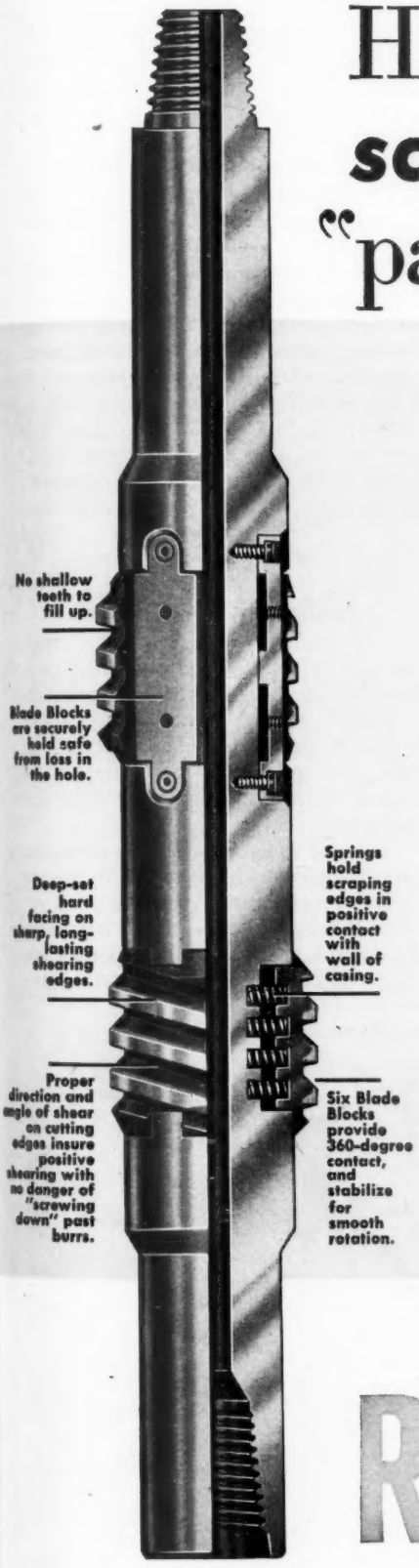
When casing pressure control is used, a saw-tooth pressure cycle is recorded. This is the result of opening and closing the tubing at regular intervals.

Conditions in Newcastle Field

Fields in the Newcastle, Wyoming, area, covered in this report, have solution gas expansion drive reservoirs and



Here's why
SCRAPING YOUR CASING "pays off"


No shallow teeth to fill up.
Blade Blocks are securely held safe from loss in the hole.
Deep-set hard facing on sharp, long-lasting shearing edges.
Proper direction and angle of shear on cutting edges insure positive shearing with no danger of "screwing down" past burrs.
Springs hold scraping edges in positive contact with wall of casing.
Six Blade Blocks provide 360-degree contact, and stabilize for smooth rotation.

Unless the inside of your casing—the vital "working surface"—is clean and smooth, there is always a possibility of trouble in future operations. Burrs from gun-shot perforations, hardened cement or mud, and even mill scale are all dangerous when the time comes to run testers or swabs, or to set retainers or packers of any description.

The Baker Model "C" ROTO-VERT Casing Scraper removes undesirable obstructions from the inside of the casing, leaving it clean and smooth. Burrs or imbedded bullets are sheared away; cement, mud and scale are scraped away, so that any down-hole work can be safely done at once, or during the years to come.

SCRAPE WHILE DRILLING OUT

The ideal time to use the ROTO-VERT Casing Scraper is during the drilling out of cement, at which time it is run as a "follow-up" behind the bit. Thus in a single run you can also remove all hardened cement, mud, burrs and scale which might later damage swabs or testers, and cause packers or retainers to set prematurely—or never set at all.

EASY TO RUN—LOW-COST RENTAL

The Baker ROTO-VERT Casing Scraper is simple to run, and will effectively clean the inside of the casing *when either rotated or reciprocated* (vertical action). No service man is required, and the low rental cost is paid for many times over by freedom from future damage to bailers, swab rubbers and packers, as well as by the elimination of future delays and re-running expense.

BAKER OIL TOOLS, INC.
HOUSTON • LOS ANGELES • NEW YORK
Call Baker for consultation and service . . .

BAKER ROTOVERT
CASING SCRAPER
PRODUCT NO. 620-C

P·E·S·A PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION PARTNERS IN PETROLEUM PROGRESS

XUM

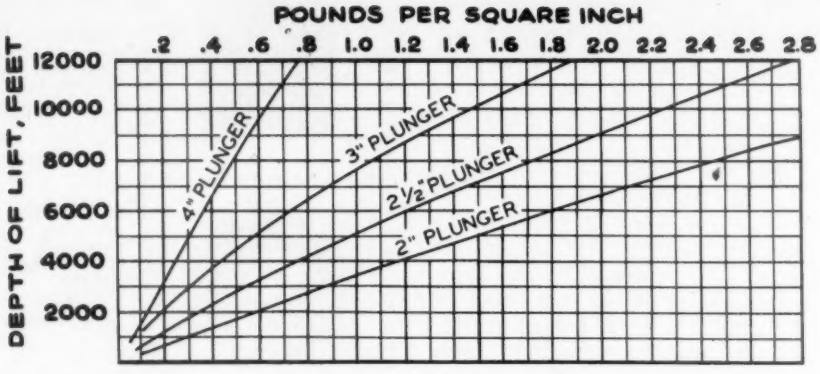


FIG. 5. Chart for determining the operating pressure required to lift one barrel per day with plunger lift. Follow line giving depth of lift in feet to intersection with curve showing size of plunger chosen. Read up from this point, to find the operating pressure in pounds per square inch. To this pressure, add any back pressure of trap and flow line plus the weight of gas column.

characteristically, gas-oil-ratios become higher as formation pressure declines. Gas in solution reservoirs result in the lowest recovery by primary production methods of any of the reservoir drive mechanisms. Any step that can be taken to insure greater primary recovery and cheaper operation is worthy of consideration.

Oil in these fields is 40 to 45 deg gravity and paraffin base. In some flowing wells tubing will paraffin up completely in three or four days. Many wells are placed on the pump in an attempt to remedy paraffin problems, some succesfully, but others not.

Bottom hole pressures are initially normal but decline rapidly as does the production. Conservation measures to insure maximum recovery are for the most part neglected, and this greatly assists the rapid decline.

Case of a Typical Well

As an example of what can be done with plunger lift, consider a well with a gas-oil ratio of 350 cu ft per barrel per 1000 ft of depth and with a bottom-hole pressure of about 600 to 800 lb. The well is producing about 40 bbl per day on the pump at 5000 ft.

As preparation for plunger lift, the inside of the 2½-in. tubing in the well is checked to make sure that scale, hard paraffin deposits, pinches, and bends will not prevent plunger travel. Broaches are then used to size and clean up the tubing so the plunger can travel without difficulty.

Next, surface installation of bumper housing assembly, instrument, diaphragm valve, and the necessary manifolding is installed and the well is returned to production.

Now, with the gas breaking around, the bottom stop (footpiece spring) that is used when on the pump, is dropped. After a few minutes the plunger is dropped in the well. When it has reached bottom, the instrument is set to open the diaphragm valve in the flowline, starting the plunger up the tubing with its load. After the first trip, the operating pressure is set at the desired point, letting the instrument take over automatic operation.

Production Increased

After a few days production can be expected to increase to about 55 per day, instead of the previous 40 bbl, with tubing paraffin problems no longer existing. Such was the average result in approximately 50 installations in the Newcastle area under similar conditions. Not all installations showed a production increase, because of varying well and field conditions. But the overall results were, and continue to be gratifying.

Expenses for repair parts, workover, and maintenance supplies in these installations were reduced to an average of about $250 per well per year. Previously they had been from $500 to as high as $8000 per year, not including lost production caused by downtime for stripping, paraffin removal, or repairs.

Guarding Against Freezing

These Northeastern Wyoming fields are subject to freezing temperatures, so it has been necessary to take some measures to prevent freezing of supply gas. This has been accomplished by the use of calcium chloride pots to remove some of the moisture from the gas, scrubbers, and two-step pressure reduction of casing gas down to the required 20 psi. Housing of the installations has reduced freezing problems and has provided shelter to personnel.

Economic Depletion

It is possible to deplete a well by the plunger lift method on its own formation gas. One well in the Newcastle area is now operating at 30 psi casing pressure and producing 5 bbl per day from a depth of 5500 ft. With this low operating pressure, it is, of course, essential that all possible back pressure be eliminated to allow the plunger to rise. Above all, a low operating cost is a "must," as any major expense could easily wipe out the profit of a month's production. This well has been producing for over six months at this rate and should continue for some time.

Applications Are Diversified

The plunger lift, in its own right, has diversified applications. Ideal conditions are not necessary to obtain satisfactory results. With bottom-hole pressure, gas-oil ratio, productivity index, and production potential established, a close estimate of results can be made.

In some wells, bottom-hole pressures in the neighborhood of 300 psi on original installations can give good results if the production rate is comparatively low and operating expenses are high. Of course, other conditions must

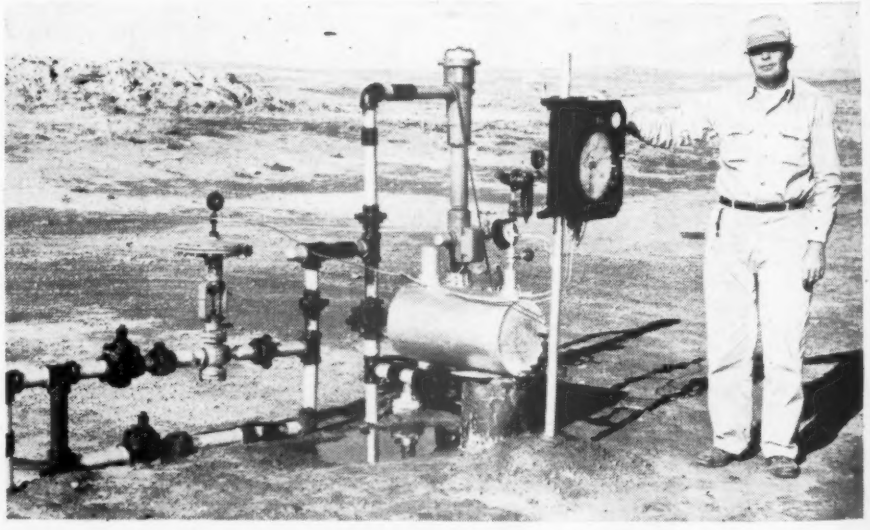
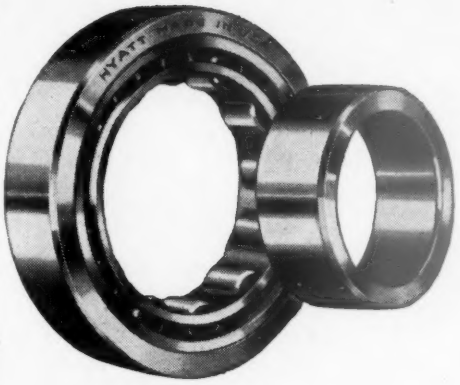
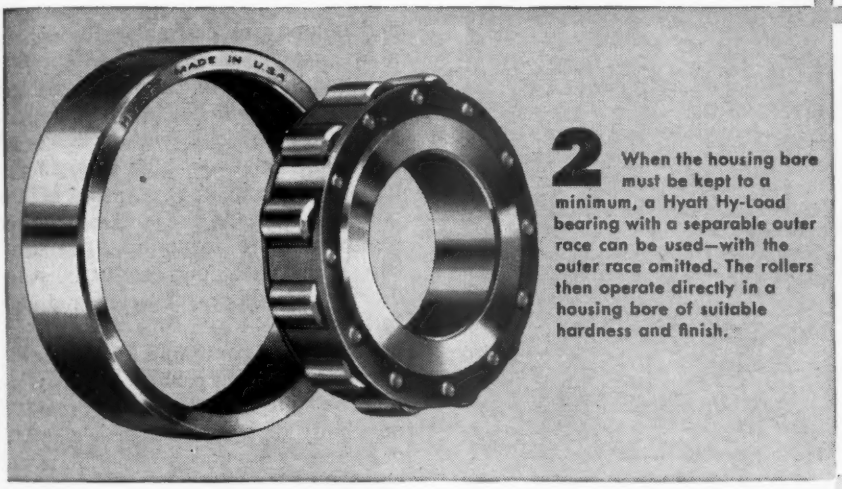


FIG. 6. Marvin Mitchell, of the Bighorn Powder Basin Corporation shown with a Type F plunger lift operating at 4600 ft in 2⅞-in. tubing. Production 60 bbl per day.

3 ways to handle your RADIAL LOAD PROBLEM

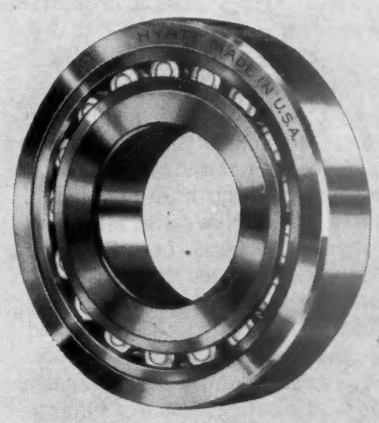


1 If your design requires a large shaft diameter to produce greater rigidity without disturbing boundary dimensions, a separable inner race type Hyatt Hy-Load bearing can be used with the inner race omitted. Rollers operate directly on a suitable hardened and ground shaft.



2 When the housing bore must be kept to a minimum, a Hyatt Hy-Load bearing with a separable outer race can be used—with the outer race omitted. The rollers then operate directly in a housing bore of suitable hardness and finish.

If your design applications involve radial loads, the best way to handle the job is with Hyatts—for Hyatt offers industry's most complete line of straight radial roller bearings! Hyatt Hy-Loads, for example, are made in three diameter series and two basic widths, to standard dimensions. There are ten major types—for the heaviest radial loads, and light or intermittent thrust loads. Four have separable inner races, two have separable outer races and four are non-separable, thus permitting wide flexibility in design and assembly procedures. Write for our general catalog No. 150—it will put the solution to any roller bearing problem at your fingertips. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



3 For designs requiring a bearing installed as a unit, there is the non-separable type of Hyatt Hy-Load. Whether you select a separable or non-separable type of Hyatt Hy-Load, they are available in a wide range of sizes.

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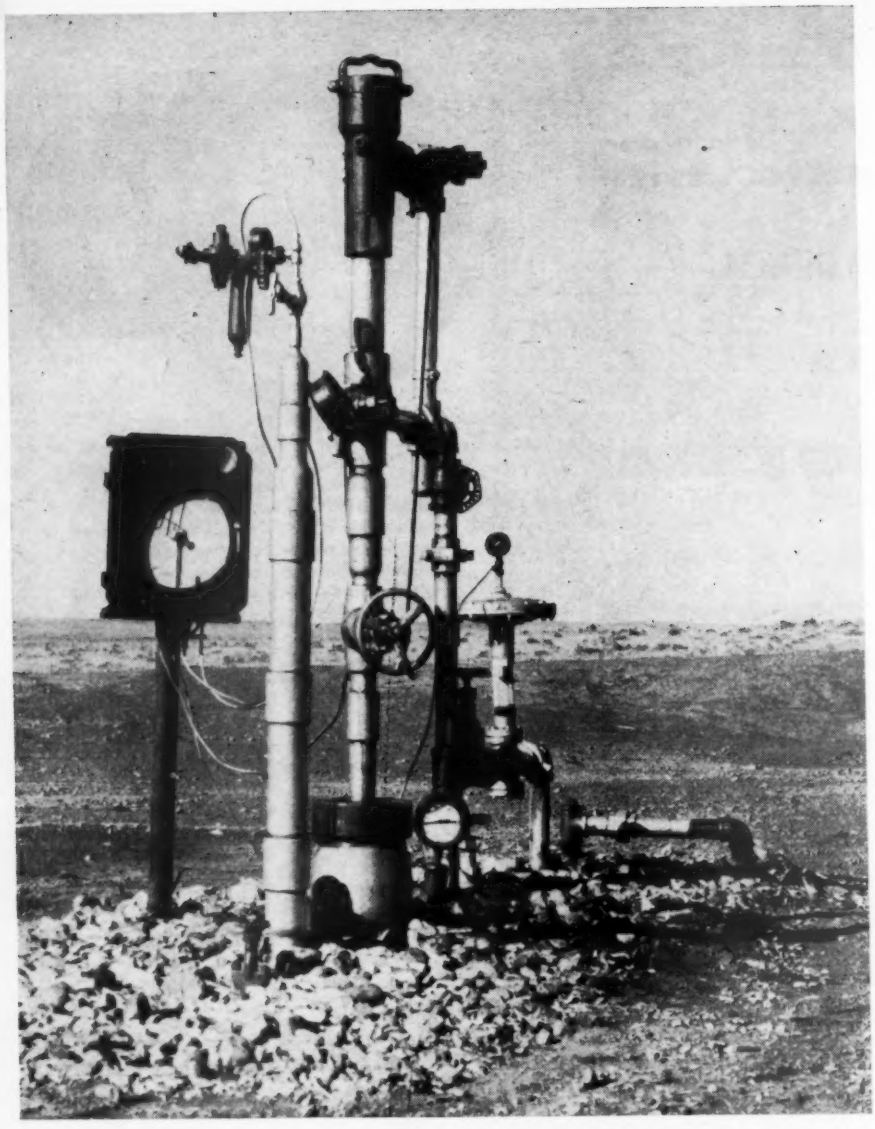


FIG. 7. Ideal Type F plunger lift operating at 3500 ft in 2⅜-in. tubing. Production 30 bbl per day.

be favorable. Primarily there must be sufficient gas-oil ratio, either from formation or supplemental gas.

Prevention of paraffin accumulation within the tubing has been completely successful in the Newcastle area with the plunger lift method. In wells where production rates exceed the capacity of pressure controlled operation and wells will flow, equipment has been adapted for use as a paraffin removal assembly. The equipment operates automatically on time control, the number of plunger trips being reduced to the minimum necessary to perform the function of paraffin removal.

In this type installation a gas-oil ratio may or may not be a determining factor. A strong flowing well is capable by nature of returning the plunger to the surface; however, it is necessary to control the number of trips and shut-in periods so that loading-up is not encountered and yet anticipated production can be attained. Weak flowing wells with low gas-oil ratios are definitely not suitable for this type operation. Strong flowing wells with low gas-oil ratios may be suitable.

Strong flowing wells which periodically die because of bottom hole water accumulation may be helped by the plunger and its ability to continually produce this water from the well. This may be accomplished by either pressure or time control. A high bottom hole pressure usually exists in this type of well and gas-oil ratio is not necessarily an important factor.

Some miscellaneous conditions which have been encountered with success are production of fair amounts of sand, considerable mud, and reduction of emulsions.

Summary of Essentials

It is not the intention of the writer to present the plunger lift as a cure-all. If conditions justify its use, however, results from good to excellent can be obtained. It is rather difficult to present in anything other than an extremely lengthy article the complete possibilities of this equipment and the various conditions necessary for these possibilities. Here is a summary of the essentials for normal pressure control operation:

(1) Normal pressure operation is based upon having a minimum of 350 cu ft of gas per barrel per 1000 ft of depth either by formation or injected gas.

(2) Enough bottom-hole pressure must be present to allow sufficient operating pressure (casing pressure at the surface) and still effect a pressure differential across the producing formation.

(3) Potential production must be within the capacity of the lift. Barrels per day capacities, which conditions may alter either way, are roughly:

Size Tubing	6000 ft	8000 ft	10,000 ft
2	100	75	50
2½	200	150	125
3	350	300	250
4	700	600	500

(4) Low productivity indices (0.2 and below) are desirable although in many cases not essential.

Deviations from the above normal conditions would be: (a) high bottom hole pressure wells with low gas-oil ratios and relatively high productivity indices wherein the purpose of the plunger is paraffin prevention or water removal, and (b) low bottom-hole pressure wells with low productivity indices, sufficient gas-oil ratios, and high lifting costs.

The normal conditions and the deviations must present problems of production, or stated another way, present a possibility of a more favorable operation, before the plunger lift has an application.

Four Main Problems Solved

In the case of a downwell pump that is inefficient because of the presence of gas, a piston utilizing the gas to remove the oil will usually increase production.

Paraffin accumulations in the tubing of either flowing or pumping wells that decrease production and increase expenses can be eliminated by a plunger running through the tubing.

A well that is dying from water or mud accumulations can be kept alive and producing by introducing a piston to remove the water or mud.

A well that flows weakly because of gas slippage through the oil can have its flowing life prolonged and its production increased by a piston that utilizes the gas to lift the oil that ordinarily would remain in the hole.

Depth limitations have not been defined as yet, but now range between 2500 and 11,000 ft. The same equipment would be used on the minimum or maximum depth ranges with the likely exception of the pressure spring or burdon tube within the instrument.

* * *

Fracturing With Acid in West Texas

Thickened emulsions with propping agent prove valuable adjuncts to carbonate treatments in Permian Basin

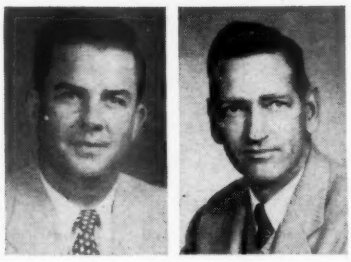
J. B. LIVINGSTON and W. L. GROSSMAN

EXCLUSIVE

DURING the last 20 years, treating of oil and gas bearing carbonate rocks with hydrochloric acid to obtain increased oil or gas productivity has become an industry accepted procedure. Constant improvement of this technique has been accomplished through use of chemical compounds to inhibit the creation of emulsions in the formation, use of wetting agents to increase the penetrating qualities of the acid, use of inhibitors to protect both surface and subsurface equipment, and use of high pressure pumping equipment with increased horsepower engines to drive the pumps.

In 1949 a new concept of oil or gas

The Authors



J. B. Livingston W. L. Grossman

J. B. Livingston is division engineer for Halliburton Oil Well Cementing Company, Lubbock, Texas. He has been with Halliburton since 1946, and since that time has had three years experience in acid work; two years in cementing; two years in fracturing work and one year as division engineer.

Prior to his employment with Halliburton, he served four years with the Armed Forces during World War II. He received a BS degree at Wofford College in 1942.

Waldo L. Grossman is division engineer and assistant division manager, West Texas division, Halliburton. He was graduated from Oklahoma University in 1940, and for the next three years was employed by Tide Water Associated. He served three years in the U. S. Navy, joining Halliburton in 1946.

TABLE 1. Treatment and results in West Texas wells.

Gallons Thickened acid	Sand lb/gal.	Tubing or casing size in.	Depth treated	Perforations or open hole	Flush oil bbl	Injection rate bbl per minute: Thickened acid	Injection rate bbl per minute: Flush oil	Maximum pressure	Production: Before treatment	Production: After treatment	Remarks
FORMATION: CRETACEOUS								**FIELD: TOBORG**			
750	2	2	376–396	Open hole	5	4.0	2.5	400	4 oil	33 oil	
750	2	2½	479–500	Open hole	90	4.0	11.0	450	4 oil	6 oil	2 months after treatment back to 4 bbl.
750	2	2½	455–478	Open hole	90	6.25	10	1000	2 oil	17 oil	One month after treatment, 20 bbl.
1000	2	2½	475–480	Open hole	100	5	6	400	2 oil	10 oil	One month after treatment, 8 bbl.
1000	2	7	388–418	Open hole	88	5	8	100	1 oil	2 oil	
750	2	2½	467–515	Open hole	80	5.5	8	500	2 oil	20 oil	
750	2	2½	306–393	Open hole	134	4.5	5	600	3 oil 4 water	10 oil 6 water	
FORMATION: YATES								**FIELD: SHAFTER LAKE**			
4000	1	2	3105 3139	Perf.	90	5.6	5.6	3700	No test	Allowable in oil.	
FORMATION: GRAYBURG								**FIELD: McCAMEY**			
3000	1	2½	1899–2105	Open hole	—	6.25	—	1000	4 oil 2 water	5 oil 5 water	
FORMATION: GRAYBURG								**FIELD: MIDLAND FARMS**			
3000	2	2½	4602–4679	Open hole	35	8.0	8.0	2500	27 oil	60 oil	
3000	2	2½	4570–4739	Open hole	140	6.25	7.0	2200	10 oil	101 oil 16 water	
3000	2	2½	4636–4810	Open hole	80	6.8	10.0	2000	33 oil	33 oil	
5000	2	2½	4650–4982	Open hole	140	6.25	4.7	2600	33 oil 5 water	37 oil	Sand pump and sand left in hole. Top of fish at 4796.
3000	2	2½	4588–4753	Open hole	127	8.3	10.0	2000	8 oil 0 water	3 oil 84 water	
FORMATION: GRAYBURG								**FIELD: NORTH COWDEN**			
3000	2	2½	3955–4200	Open hole	180	5.0	10.0	3500	22 oil pump	82 oil flow	Allowable: Before 39 After 61
3000	2	2½	4120–4525	Open hole	184	5.9	10.0	4000	11 oil pump	90 oil pump	Allowable: Before 13 After 38
3000	2	2½	3941–4200	Open hole	135	4.4	9.0	3500	16 oil pump	182 oil flow	
3000	2	2½	4016–4433	Open hole	170	8.3	11.3	—	12 oil pump	158 oil flow	
3000	2	2½	4304–4857	Open hole	225	8.3	8.3	3200	11 oil pump	100 oil 5 water pump	
3000	2	2½	4081–4383	Open hole	215	6.0	10.75	3450	26 oil pump	201 oil flow	
3000	2	2½	3972–4210	Open hole	269	4.75	10.75	3700	6 oil pump	115 oil	Allowable: Before 6 Marginal After 44
4000	2	2½	3949–4210	Open hole	216	7.0	9.0	3200	4 oil	73 oil 62 water	Allowable: Before 4 Marginal After 42
3000	2	2½	4250–4350	Open hole	260	5.3	9.6	2800	14 oil	111 oil 146 water	Allowable: Before 14 After 30
3000	2	2½	4318–4516	Open hole	180	6.8	11.2	3500	10 oil	101 oil 16 water	Allowable: Before 10 After 31
3000	2	2½	3949–4212	Open hole	200	6.5	10	3000	15 oil pump	331 oil 175 water Flow on 18.64 choke	Allowable: Before 15 After 53
3000	2	2½	4230–4420	Open hole	235	7	10	3200	10 oil	35 oil	
3000	2	2½	3991–4300	Open hole	211	6.5	10.5	3200	15 oil	76 oil 12 water	50 bbl allowable
FORMATION: GRAYBURG								**FIELD: JACKSON**			
3000	2	2	2543–2555	Perf.	33	5.2	5.2	4000	No test	51 oil	

production stimulation was introduced for sand producing formations. Hydraulic fracturing of petroleum producing sands by pumping a viscous fluid carrying a mechanical propping agent has now become an industry accepted method. Shortly after the early success of this method, consideration was given to the possible merits of using a thickened or viscous acid to improve the effectiveness of normal acid treatments. Materials to form a viscous acid were developed and this particular material was first used in the Permian Basin during the latter part of 1950.

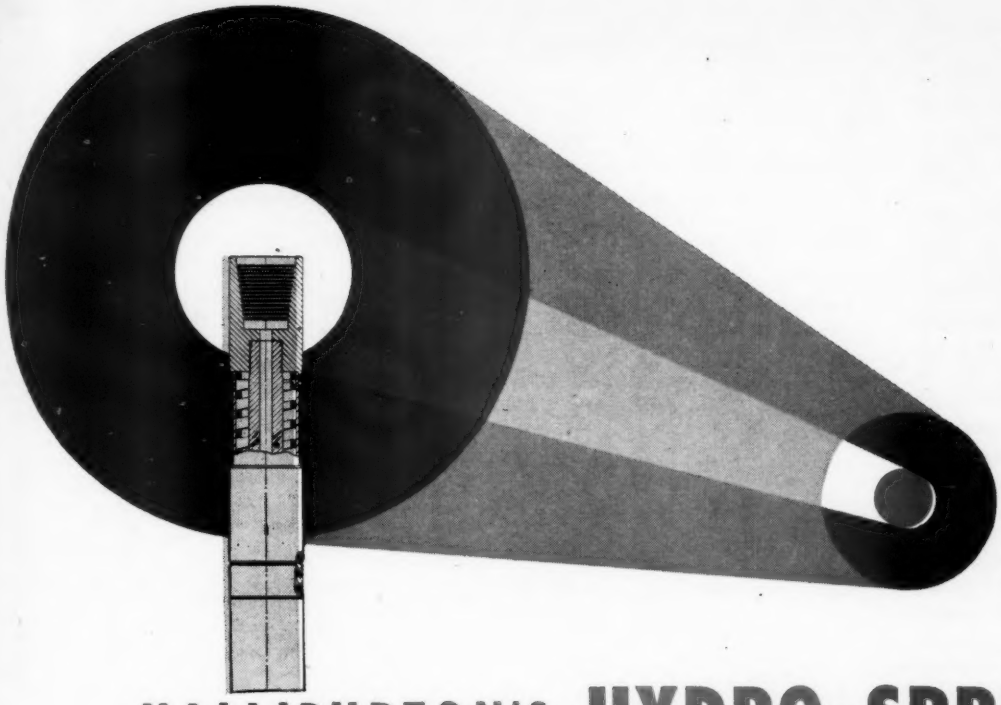
This type of thickened acid* is an emulsion formed by mixing hydrochloric acid, a hydrocarbon (usually kerosine) and a powder type emulsifying agent. The emulsion formed is an acid in oil emulsion. The strength of the acid phase of the mixture may be varied depending upon the solubility of the formation to be treated. Fifteen per cent acid has been used for most of the treatments in this area. Viscosity of the emulsion may be controlled by changing the ratio of hydrocarbon and acid or by changing the amount of emulsifying agent. The thickened acid will revert to a thin fluid by one or more of three methods. Chemical reaction with a lime or dolomite formation will cause the material to thin to the viscosity of regular acid. Dilution with crude oil also reduces the viscosity of the emulsion. An external breaker may also be pumped ahead or behind the thickened acid for this purpose.

Thickened acid as a fluid used in treating oil wells has several desirable characteristics. First, it may be mixed to a high viscosity generally considered desirable for the forming or extending of fractures in the formation. This viscosity may be an aid in diverting regular treating acid into new zones. Second, it has excellent sand carrying qualities. As much as four pounds per gallon of sand has been mixed in the solution at the home station of the service equipment before going to the well location, thereby eliminating the mixing on location. The same type of sand, mechanical propping agent, is used with thickened acid as has been used with other hydraulic fracturing methods. It is a round grained Ottawa sand, graded to pass through a 20-mesh screen and be retained on a 40-mesh screen. The average grain diameter is about 0.020 in. Third, even though it is an emulsified acid, equal reaction with the formation is obtained as would be expected from a comparable amount of regular treating acid. In addition to these known characteristics, theory would indicate, even though it has not been proved, that due to the nature of the emulsion, it could be placed farther into the formation before reaction is

*Acidfrac.

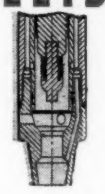
TABLE 1 (Continued). Treatment and results in West Texas wells.

Gallons Thickened acid	Sand lb/gal.	Tubing or casing size in.	Depth treated	Perforations or open hole	Injection rate bbl per minute: Flush oil bbl	Injection rate bbl per minute: Thickened acid	Injection rate bbl per minute: Flush oil	Maximum pressure	Production: Before treatment	Production: After treatment	Remarks
FORMATION: GRAYBURG								**FIELD: SKAGGS**			
2000	2	2	3847–3960	Open hole	75	3	4.5	3700	11 oil	11 oil	
FORMATION: SAN ANDRES								**FIELD: ADAIR**			
3000	2	5½	4795–4885	Perf.	125	6	6	1500	7 oil	36 oil	
3000	2	5½	4795–4885	Perf.	130	8	8	500	5 oil	35 oil	
FORMATION: SAN ANDRES								**FIELD: BRAHANEY**			
4000	2	2	5174–5202 5218–5260	Perf.	70	5	5	5600	No test	87 oil	
FORMATION: SAN ANDRES								**FIELD: CEDAR LAKE**			
3000	2	2	4382–4768	Open hole	50	4	4	2000	16 oil	80 oil	
3000	2	2	4640–4870	Open hole	50	4	5	4700	32 oil	90 oil	
FORMATION: SAN ANDRES								**FIELD: DEAN**			
3000	2	2	4968–5048	Open hole	150	2	5	3400	No test	130 oil	
FORMATION: SAN ANDRES								**FIELD: GOLDSMITH**			
3000	2	2	4220–4255	Open hole	126	2.0	5.3	4100	16 oil	86 oil	GOR: Before 5000 After 2948
3000	2	2½	4161–4187	Open hole	100	6	7.7	2800	3 oil	15 oil 112 water	
3000	2	2½	4175–4210	Open hole	125	5.5	5.5	—	2 oil	16 oil*	Tubing plugged during treatment. GOR before 3542; after 42,127. Previous high GOR had been reduced by plastic squeeze job.
FORMATION: SAN ANDRES								**FIELD: IATAN, EAST**			
3000	½	2	2455–2490 2506–2533 2560–2570	Perf.	200	4.7	7.4	3500	—	39 oil 10 water	Initial treatment after deepening and setting liner to repair casing leak.
FORMATION: SAN ANDRES								**FIELD: LEVELLAND**			
2000	2	2	4770–4833	Open hole	116	2	4.5	2900	23 oil	83 oil 16 water	
2000	1	2	4775–4862	Open hole	150	215	5	3400	23 oil	83 oil 10 water	
FORMATION: SAN ANDRES								**FIELD: LOCO HILLS**			
4500	2	2	2988–3178	Open hole	80	4	5	2400	2 oil	All water	
FORMATION: SAN ANDRES								**FIELD: SEMINOLE**			
3000	½	2	4991–5236	Open hole	75	2	3.5	4950	23 oil	121 oil	
FORMATION: SAN ANDRES								**FIELD: SLAUGHTER**			
2000	2	2	4963–5078	Open hole	148	4.8	4.8	4100	No test	130 oil	
2000	2	2	4951–5031	Open hole	150	3.3	3.3	3900	No test	80 oil	
FORMATION: SAN ANDRES								**FIELD: S. LOVINGTON**			
2500	1	2	4587–4972	Open hole	125	5	5	4200	3 oil	Allowable	
FORMATION: SAN ANDRES								**FIELD: WASSON**			
3000	2	2	5091–5237	Open hole	35	3.5	3.5	3100	7 oil	30 oil	
FORMATION: SAN ANDRES								**FIELD: YELLOWHOUSE**			
2000	1	2	4600–4643	Open hole	200	3.5	5	3600	16 oil	144 oil	
2000	3	5½	4577–4647	Open hole	200	6.6	6.6	1800	16 oil	80 oil	
4500	2	211	4523–4593	Open hole	118	4	4	2800	New well	200 water	
FORMATION: HOLT								**FIELD: NORTH COWDEN (Deep)**			
3000	2	2½	5138–5218	Open hole	228	8.3	10.3	2800	Swab 5 hr. Recover 11 bbl oil.	159 oil pump	New well.
3000	2	2	4330–4420	Open hole	148	5.75	6.0	3200	10 oil	48 oil 2 water	3 months after treatment; 48 oil & 2 water
3000	2	2½	4318–4505	Open hole	151	5.75	10.0	3000	0 oil 0 water	15 oil 16 water	3 months after treatment; 8 oil & 8 water
3000	½	2½	5155–5218	Open hole	190	6.75	8.3	2700	17 oil 0 water	11 oil 87 water	
3000	None	2	5241–5278	Perf.	212	5.0	7.0	4100	—	144 oil	New well.



SUREST WAY TO FIND MOST PRODUCTIVE ZONE

HALLIBURTON'S HYDRO-SPRING TEST



It costs so little and saves so much that many operators run a Hydro-Spring Test even in proven areas. There's no surer way to find your most productive zone.

Giving due credit to surface geology, core records, and electric logs, their findings are confirmed only when the Hydro-Spring Tester and the Bourdon Tube Pressure Recording Device come up with the final answer.

With so much at stake you want the best drill stem test—and Halliburton has it in Hydro-Spring.

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Perfect performance, with rarely a mis-run, saves you time, trouble, money. Hydro-Spring opens easily by weight of drill pipe only and gives positive surface indication. Smoothest test you ever ran.

Reaches bottom easier and can be run in faster, even in tight holes. Equalizing By-Pass reducēs possibility of damaging formation, prevents fluid loss to formation.

Precise pressure recording, most accurate available, provided by Bourdon Tube on special copper plate that is laboratory checked. Included with Standard Recording at no extra charge.

Instant Packer Release—no jarring or pulling the new Expanding Shoe Packer. Steel sole of shoe prevents rubber extruding beyond working limits, leaves little or no rubber in hole.

Support your decision with the best in drill stem testing—Halliburton's Hydro-Spring. It provides the four most important features, is first choice with the most operators, is the only testing service backed by 30 years' research and two-million-job experience. And it's more available—with 211 service centers in this country alone. Phone your local or district Halliburton office, just minutes away. Or contact Halliburton Oil Well Cementing Company, Duncan, Oklahoma.

Hydro-Spring Tester—Patent Applied For

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complete than could be expected with regular acid. The fact that oil is the outer phase of the emulsion may serve as an inhibitor for the protection of surface and subsurface equipment.

Thickened acid was first used, in connection with acid treatments, as an aid in placing regular acid in untreated portions of pay formations. The method used was that of pumping 500 or 1000 gal of thickened acid followed by larger volumes of regular treating acids. By using this method it was believed that the thickened acid, due to its high viscosity, would enter the more porous or previously treated zones and cause enough build-up in pressure to force the regular treating acid into untreated areas.

After using thickened acid to aid in diverting regular treating acid into new sections of the producing formation it was found that better results would be obtained if solid particles were added to provide more sealing effect in the more porous zones. A temporary plugging agent that is completely soluble in crude oil, was added for this purpose. Normally about 2 lb per gallon of this material is used.

Also about this time thickened acid was used to precede oil on oil squeeze jobs. These jobs were performed by pumping 500 or 1000 gal of thickened acid into the formation followed by some 200 or 300 bbl of oil at relatively high injection rates.

In May 1952 sand was added to thickened acid used to precede regular acid in treating lime wells. One-half or one pound of sand per gallon was added to 500 or 1000 gallons of thickened acid which was followed by larger amounts of treating acid.

Since the beginning of 1953 the tendency has been, where thickened acid is used, toward the use of larger quantities of thickened acid carrying from one quarter to 3 lb of sand per gallon and eliminating the use of regular treating acid as part of the treatment. As of November 1, 1953, the largest treatment was 8500 gal of thickened acid carrying two pounds of sand per gallon. Average job at that time was 4000 gal with an average sand content of one and one-half pounds per gallon.

Table 2 is a partial list of the formations that have been treated with thickened acid. Practically every producing formation in this area, from the shallow Cretaceous pay in the Toborg field of Pecos County which produces at a depth of about 450 ft, to the Ellenburger (Ordovician) which produces from about 12,500 ft in the Midland Farms field of Andrews County, has responded to this type of stimulation.

When hydraulic fracturing methods of stimulation were first introduced to

TABLE 1 (Continued). Treatment and results in West Texas wells.

Gallons Thickened acid	Sand lb/gal.	Tubing or casing size in.	Depth treated	Perforations or open hole	Injection rate bbl per minute: Flush oil bbl	Injection rate bbl per minute: Thickened acid	Injection rate bbl per minute: Flush oil	Maximum pressure	Production: Before treatment	Production: After treatment	Remarks
FORMATION: CLEARFORK								**FIELD: GOLDSMITH 5600**			
2000	½	2	5440–5690	Perf.	121	1.3	2.0	3500	13 oil	109 oil	Allowable before 36 bbl and 77 bbl after treatment. Treated throughsidedoorck.
3000	2	2	6225–6385	Open hole	136	1.9	6.5	3050	—	226 oil	New well.
4000	2	2½	5608–5775	Perf.	310	2.5	1.4	5000			
2000	½	2	5500–5710	Perf.	122	1.5	3.0	3000	23 oil	83 oil	Allowable before 28 bbl with 5117 GOR and 45 bbl after treatment with 3462 GOR. Treated throughsidedoorck.
2000	½	2½	5844–5580	Perf.	105	2.0	4.3	3100	88 oil 9 water	79 oil in 8 hrs.	101 bbl allowable. Prod. before treatment, flow through tubing. After, flow through annulus. Dual completion. Treated through side door choke.
3000	½	2½	5460–5778	Perf.	100	2.0	4.2	2200	39 oil	25 oil 4 water	38 bbl allowable. Prod. before treatment, flow through tubing. After, flow through annulus. Dual completion. Treated through side door choke.
2000	½	2	5470–5720	Perf.	120	2.0	3.0	3200	28 oil	35 oil	Allowable before, 35 bbl;after, 35 bbl. Treated through side door choke.
FORMATION: WOLFCAMP								**FIELD: TOWNSEND**			
5000	2	2	10305–10427	Perf.	135	3.75	2	5800	0	192 oil	
FORMATION: WOLFCAMP								**FIELD: HUTTO**			
5000 (2000) (3000)	None ½	2½	7370–7430	Perf.	254	5.0	8.2	3600	8 oil	17 oil	
FORMATION: PENNSYLVANIAN								**FIELD: WELLMAN**			
1500	2	2	9890–9904	Perf.	41	1	1	5000	None	None	
3000	2	2	9874–9884 9900–9926	Perf.	70	5	3	4500	None	Water	
FORMATION: PENNSYLVANIAN								**FIELD: BOND (Canyon)**			
3000	None	2	8918–8933	Open hole	135	2.5	5.4	3300	—	71 oil 5 water	Upper zone previously treated 2500 regular acid. 2000 regular acid used ahead of thickened acid.
FORMATION: DEVONIAN								**FIELD: W. DOLLARHIDE**			
3000	2	2	7870–7970	Perf.	45	2	2	4500	New well	None	
FORMATION: SILURIAN								**FIELD: GOLDSMITH (North)**			
2500	2	2½	8040–8075	Perf.	100	4.5	1.8	6500	8 oil	75 oil	
FORMATION: ELLENBURGER								**FIELD: FOWLER**			
1500	2	2	10,058–10,082 10,152–10,188 10,214–10,222	Perf.	70				0	40 oil	
FORMATION: GRAYBURG								**FIELD: MIDLAND FARMS**			
3000	2	2	4600–4748	Open hole	60	8	8	1900	22 oil	84 oil	
FORMATION: ELLENBURGER								**FIELD: MIDLAND FARMS**			
4000	2	2	12,643–12,669	Perf.	50	4.6	4.2	5500	—	598 oil in 14 hr.	
4000	1	2	12,536–12,580	Open hole	85	3.7	3.7	5000	—	393 flow	Treated with 1000 gal. 15%. Immediately prior to this treatment maximum pressure was 5500. Potentialed for 393 BOPD.

TABLE 2.

Formation	Field	County
Cretaceous	Toborg	Pecos
Yates Sand	Shafter Lake	Andrews
Grayburg	Foster	Ector
	Furhman Mascho	Andrews
	Mabee	Andrews
	McCamey	Upton
	Midland Farms	Andrews
	North Cowden	Ector
	Jackson	Eddy, New Mexico
San Andres	Adair	Gaines
	Brahaney	Yoakum
	Cedar Lake	Gaines
	Dean	Cochran
	Goldsmith	Ector
	Harper	Ector
	Iatan, East	Howard
	Levelland	Hockley
	Loco Hills	Eddy, New Mexico
	Sand Hills(McKnight)	Crane
	Seminole	Gaines
	Slaughter	Hockley
	South Lovington	Lea, New Mexico
	Wasson	Yoakum
	Yellowhouse	Hockley
Holt	N. Cowden (Deep)	Ector
Clear Fork	Anton—Irish	Lamb
	Fullerton	Andrews
	Goldsmith	Ector
	TXL	Ector
Wolfcamp	Townsend	Lea, New Mexico
	Hutto	Howard
Pennsylvanian	Wellman	Terry
	Bond (Canyon)	Howard
Devonian	Maljamar	Lea, New Mexico
	Three Bar	Andrews
	Wheller	Winkler
Silurian	Goldsmith (North)	Ector
	Midland Farms	Andrews
Ellenburger	Fowler	Lea, New Mexico
	Midland Farms	Andrews
	Wheller	Winkler

the industry, the selection of wells for treatment was quite often made on the basis that if the treatment was not successful, the well would not be harmed because it was about to be abandoned. A great number of the earliest wells treated using thickened acid were of this same general class. Two factors, however, have led to a reversal of this type of thinking. First, the high degree of success associated with hydraulic fracturing in sand producing wells; second, the economic factor. Many old wells' allowable production is related to its initial potential. Consequently a 20 bbl producer with a possible allowable of 50 bbl is a better prospect than a 5 bbl well with a possible 20 bbl allowable. It is quite evident that if a 300 per cent increase was obtained in each case that a pay out would be obtained in one third the time on the initial 20 bbl producer. Successful application of these materials to old producing zones quite naturally led to their use for initial well completion stimulation.

Most treatments, either open hole or through casing perforations, are performed with a packer in the well. Generally a single packer with some type of hold down device is used, and the materials are pumped down the tubing. Exceptions to the general rule range from multitude of dual packer arrangements plus accessory treating subs to simple treatments down the casing. Because of the relatively high viscosity to which the emulsion is normally mixed, as large a size of tubing or no tubing if practical should be used to reduce the horsepower loss to fluid friction. Injection rates of 10 bbl per minute are quite common when 2½-in. or larger size tubing is used. Results of treatments in a number of the fields listed previously are shown in the tabulation accompanying.

It is estimated that more than 40,000 hydraulic fracturing treatments of all types have been performed since their introduction commercially. At the present time about 2500 jobs of this type are done each month. Although the major portion of this work is on sand producing formations, the application of thickened acid as a fracturing medium is ever increasing. Thickened acid is one of the tools in the hydraulic fracturing family which may be used in formations from zero to 100 per cent solubility to successfully increase the ultimate primary recovery of oil from many reservoirs. * * *

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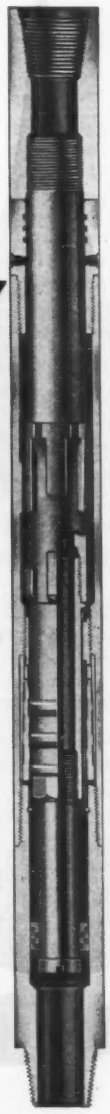

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Relationship Between Porosity and Chemical Composition of Carbonate Rocks

Dolomitization may influence porosity. Studies indicate possibility of thus predicting porosity through chemical examination of rocks

GEORGE V. CHILINGAR and RICHARD D. TERRY

Porosity Through Dolomitazation

As pointed out by Hohlt,[5] there is no agreement concerning the origin of porosity through diagenetic and epigenetic dolomitization. Lauer,[9] Hennen and Metcalf,[4] Lloyd, [12] and Howard and David[7] favor the theory of volume shrinkage through dolomitization, whereas Murray,[13] Landes,[8] and many other outstanding geologists oppose it mainly because there is lack of field evidence. Lindgren,[11] who is the proponent of volume for volume replacement, also does not believe in volume shrinkage.

In order to solve this problem the authors attempted to show a correlation between the percentage dolomitization and porosity of Lower Miocene, Asmari Limestone of Iran which was previously reported as lacking such relationship.[10] The statistical study of this limestone showed dependence of porosity on the degree of dolomitization (Fig. 1).

The percentage dolomitization has been calculated from the $CaCO_3$ and $MgCO_3$ content of samples which were determined by the Versenate method.[2] In addition to plotting individual values of 79 samples, the average porosity of samples having a range in dolomitization of 0-10, 10-25, 25-50, 50-75, and 75-90 also have been plotted against average degree of dolomitization. There is no simple and direct relationship, however, between the porosity and degree of dolomitization which would exist in an ideal case when all porosity is caused by dolomitization. Theoretically, the molecular replacement of calcite by dolomite results in a shrinkage of 12.1 per cent by volume. The lack of perfect correlation is probably due to the existence of some pores prior to dolomitization.

Hohlt,[5] who made a comprehensive research on the subject, believes that there is ample field evidence of volume shrinkage in dolomites. Review of the literature also shows that many limestone oil reservoirs produce largely from the dolomitic facies. The absence of porosity in primary dolomites also is a very strong argument in favor of porosity through dolomitization.

The Authors

G. V. Chilingar R. D. Terry

George V. Chilingar is a teacher in the petroleum engineering department of the University of Southern California. A native of Iran, Chilingar graduated from the University in 1949 and later received a MS in 1950. He is presently completing work toward a PhD in geology with a minor in petroleum engineering.

Richard D. Terry is associated with the Allen Hancock Foundation of Marine Research. Terry has a BS from the University of Southern California and will receive his MS from University of Southern California this summer. He has been with the Foundation since 1950.

Relationship Between Chemical Composition of Carbonate Rocks and Porosity

Aprodova[1] made a comprehensive statistical study of the relationship between the porosity and the chemical composition of carbonate rocks in Molotovsk region of USSR. Her results are shown in Fig. 2.

Fig 2A shows the relationship of insoluble residue and MgO content to porosity. In accumulating the data, Aprodova tabulated the insoluble residue and MgO content of limestone samples having a certain range of porosity (0 to 1 per cent, 1 to 2 per cent, etc.). The average data for the insoluble residue and MgO content was then plotted against average porosity. The amount of insoluble residue depends to a large extent on porosity, and the content of insoluble residue becomes lower with rising porosity. The relationship between the porosity and MgO content also suggests a secondary origin for the dolomites of Molotovsk region.

In Fig 2B, the average values of porosity and MgO content have been plotted against the insoluble residues. For this purpose, Aprodova measured the porosity and MgO content of limestone samples having a certain range in the insoluble residue content (0 to 20 per cent, 20 to 40 per cent, 40 to 60 per cent, etc.). This graph shows that porosity decreases slightly with increasing amounts of insoluble residue.

Fig. 2C shows the dependence of porosity and insoluble residue on the MgO content. Apparently, porosity increases with increased dolomitization. Lack of perfect correlation suggests prior existence of some porosity.

Solution Porosity

Solution porosity is more common to dolomites, although calcite is many times more soluble than dolomite in rainwater (Chilingar, 1953).

The present investigators share the opinion of Hohlt (1948) that solution porosity is a direct function of the orientation of the mineral grains or crystals in limestones. Dilute solutions of acetic acid have been forced through cores of limestones having preferred orientation of C-axes and cores of dolomites having random orientation. It was found that porosity develops to a greater extent in dolomites. These results also lead to the conclusion that water probably moves with greater ease through the carbonate rocks having a diverse orientation of the constituent grains. Therefore, the random orientation of the constituent grains in most

EXCLUSIVE

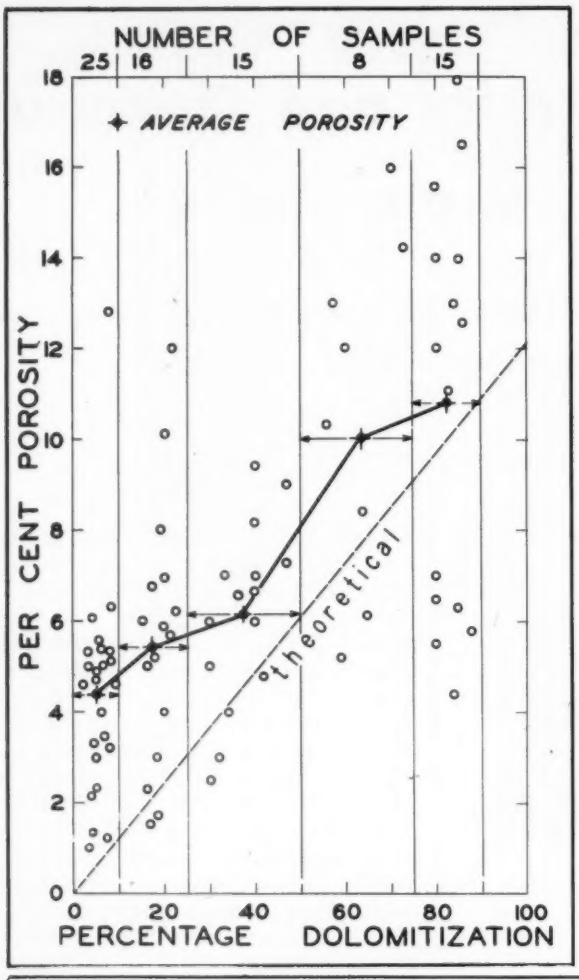

FIG. 1. Relationship between porosity and dolomitization of Asmari limestone, Iran.

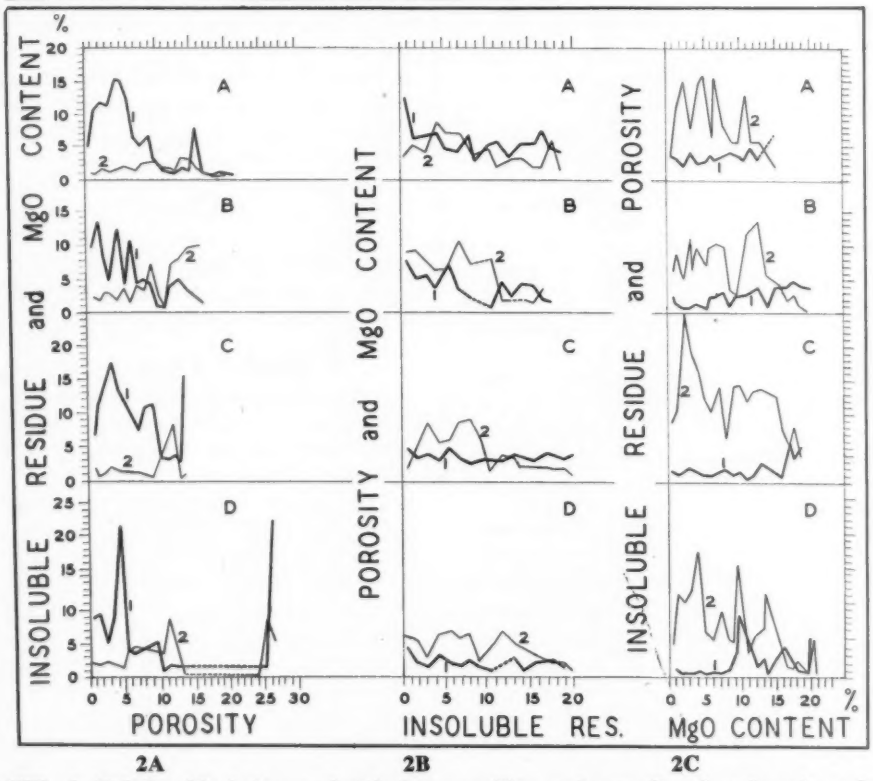

FIG. 2. Relationship between chemical composition and porosity of carbonate rocks in Molotovsk region, USSR.

2A Dependance of insoluble residue and MgO content on porosity. 1— Insoluble residue, 2— MgO content.
2B Dependance of porosity and MgO content on insoluble residue. 1— Porosity, 2— MgO content.
2C Dependance of porosity and insoluble residue on MgO content. 1— Porosity, 2— Insoluble residue.
Locality: A— Krasnokamsk, B— Nitva, C— Severokamsk, D— Poloasna

diagenetic and epigenetic dolomites might account for their higher solution porosity. The low solution porosity of primary dolomites, with the preferred orientation of grains, also proves this point. Solution of impervious limestones, instead of increasing the porosity, however, only tends to reduce the volume.

Conclusions

1. Field evidence suggests that some porosity forms through dolomitization.
2. Solution porosity develops to a greater extent in carbonate rocks with diverse orientation of the constituent grains.
3. Statistical studies will enable geologists and petroleum engineers to predict porosity of carbonate rocks. Statistical studies would also show the relationship between porosity and dolomitization for many limestones, which have been reported as lacking such relationship.

Acknowledgments

The authors are greatly indebted to Dr. K. O. Emery and Dr. C. M. Beeson for reviewing the manuscript.

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* * *

Did you know that based upon payrolls, the petroleum industry paid 35 per cent more for benefit plans (fringe benefits) than industry as a whole?

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FIG. 1.

(Fig. 1) Seven of these wildcats were completed as shut-in gas or gas-condensate wells, and one was completed as an oil well. Of the 8 new-field wildcats drilled April 1, 1954, one will probably be a new-field recovery. The structure of the area is complex with many anticlines some of which are faulted. A regional structure map of the Mississippian (Fig. 2) based on subsurface data only does not reveal the complexity of the structure, but it does show the direction of regional dip.

As most of the new gas fields in the Warrior Basin (Fig. 3) are located on seismic structures, it is apparent that structure is an important factor controlling accumulation. This article, however, will deal mainly with the stratigraphy of the Chester series in an effort to present certain stratigraphic problems of the Basin. A discussion of the entire sedimentary section of the Warrior Basin along with an explanation of the structural picture of the Basin as we now know it was given by Mellen* in his two part article published last summer. The stratigraphic

*Frederic F. Mellen, "Geology of the Black Warrior Basin," World Oil, June and July, 1953, Vols. 136 and 137.

Stratigraphic Problems in the Warrior Basin

Difficulty of formation correlation and recognition of pay sands hamper Warrior Basin exploration and development

RIZER EVERETT

The Warrior Basin of northeast Mississippi and northwest Alabama has experienced moderate wildcat drilling activity since the completion in February 1952 of the Union No. 1 Sanders as a commercial gas well. Some of the stratigraphic problems presented include: The lateral gradation of lithology and permeability of Chester sands, difficulties of correlating the Chester section, and difficulties of recognizing commercial sands. Solutions to the problems will be worked out as decline data are obtained from the newly discovered gas fields and more wildcat wells are drilled in the Basin.

FROM the completion date of February 1952 of the Union No. 1 Sanders (Fig. 6) to April 1954, 51 new-field wildcats were drilled in the Warrior Basin of Mississippi and Alabama.

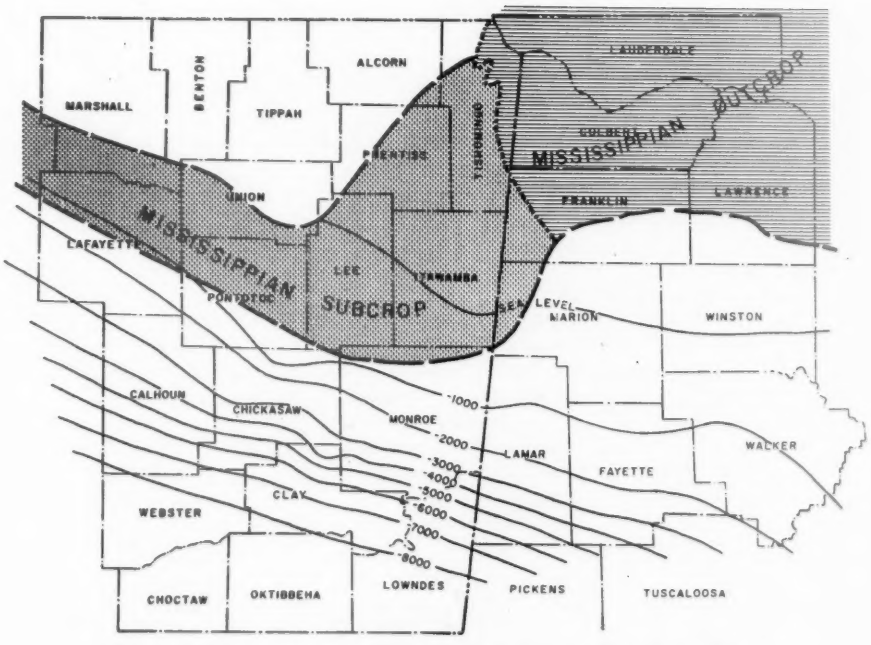

FIG. 2. Regional structure map contoured on top of Mississippian.

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FIG. 3. Index map of northeast Mississippi and northwest Alabama showing oil and gas fields and lines of cross-section.

The Author

Rizer Everett is Mississippi-Alabama district geologist for Carter Oil Company. A graduate of The University of Texas with a degree in geology, Everett joined Carter in 1937. He has worked in the states of Oklahoma, Kansas, Wyoming, Illinois, Indiana, Kentucky, Mississippi, Alabama, and Louisiana since joining Carter. Everett was senior geologist in the central division office at Oklahoma City, Oklahoma, before his transfer to Jackson, Mississippi in 1952.

problems that will be discussed are not unique to the Warrior Basin and, as has been the case in other basins, the solutions to most of the problems will be worked out by drilling additional wildcat and pool development wells.

Correlation of the Chester

In the fall of 1952 when the Paleozoic Study Group of the Mississippi Geological Society began its work on

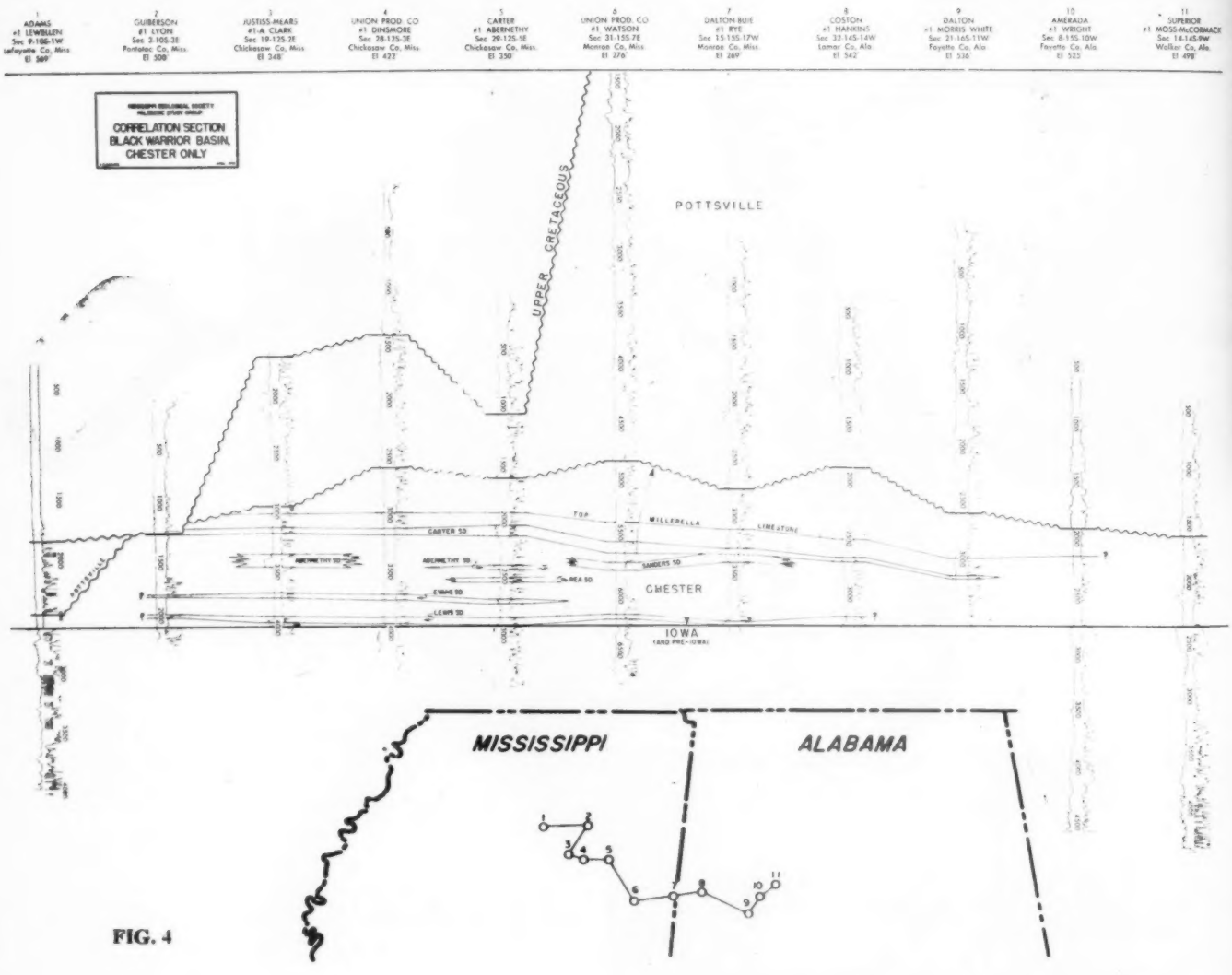

FIG. 4

NOTHING TAKES
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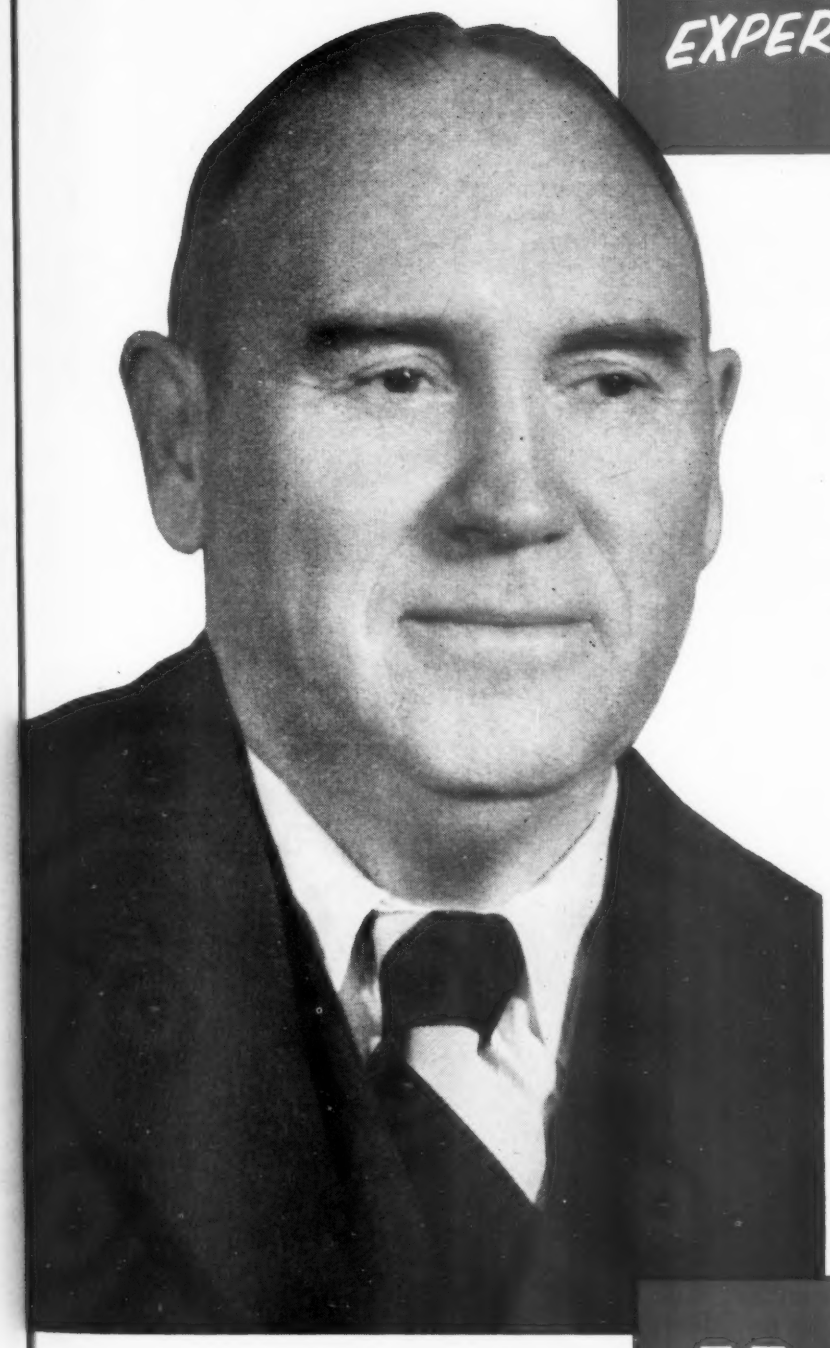

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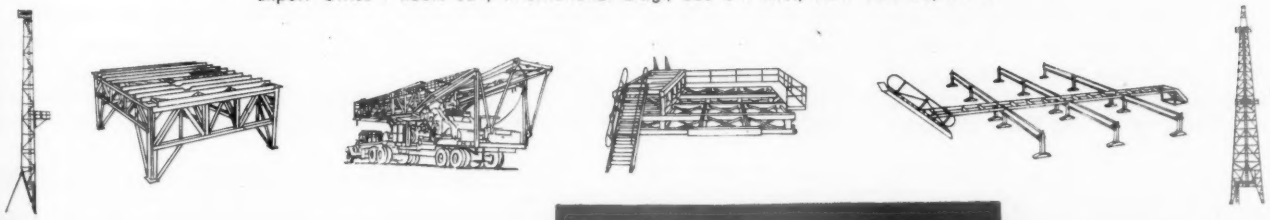

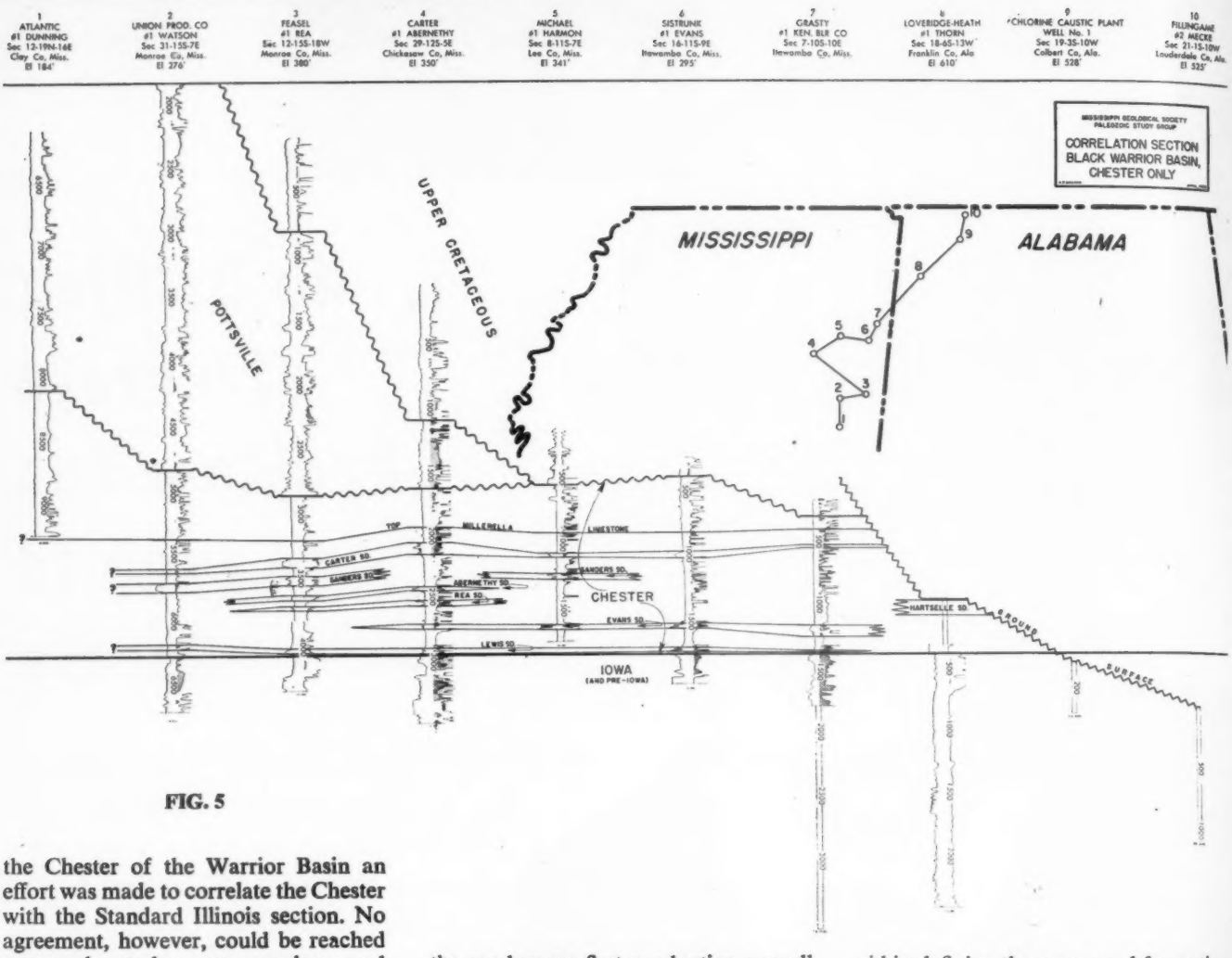
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7 GRASTY #1 KEN. BLR CO Sec 7-10S-10E Itawamba Co, Miss.
8 LOVERIDGE-HEATH #1 THORN Sec 18-6S-13W Franklin Co, Ala El 610'
9 "CHLORINE CAUSTIC PLANT WELL No. 1 Sec 19-3S-10W Colbert Co, Ala. El 528'
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MISSISSIPPI GEOLOGICAL SOCIETY PALEOZOIC STUDY GROUP
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ALABAMA
UPPER CRETACEOUS
POTTSVILLE
TOP
MILLERELLA LIMESTONE
CARTER SD
SANDERS SD
ABERNETHY SD
REA SD
CHESTER
EVANS SD
LEWIS SD
IOWA
(AND PRE-IOWA)
HARTSELLE SD

FIG. 5

the Chester of the Warrior Basin an effort was made to correlate the Chester with the Standard Illinois section. No agreement, however, could be reached among the study group members, and the matter was dropped. It was generally agreed, nevertheless, that no sediments of post-Elvira and upper Elvira age are present in the most complete section of the Chester known in the Warrior Basin. The correlation shown here (Fig. 7) does not represent the opinion of even a majority of the Paleozoic Study Group, but it does show a possible correlation based on our present knowledge. It may be altered in the future when more data are available. Absence of limes in the Warrior Basin Chester subsurface section makes correlation with the standard section very difficult.

Where the Chester rocks outcrop in northwest Alabama there is considerably more limestone present than in the Chester of the subsurface in northeast Mississippi. The lateral gradation of rocks from limestones at the surface to sands and shales in the subsurface in less than 80 miles makes it extremely difficult to be certain of the correlation of the surface Chester beds with those of the subsurface. Because of these difficulties of correlation the Paleozoic Study Group of the Mississippian Geological Society named the Chester sands shown in Fig. 7 by using the farm names of the wells in which the sands were first productive or well developed. Up to the present time 6 sand names have been adopted for use by the Society. Reproductions of the 3 cross sections made by the Paleozoic Study Group of the Mississippi Geological Society are shown in Figs. 4, 5, and 6.

Fossil Information

Even though a number of wells have cored a great deal of the Chester section in northeast Mississippi, there is at present insufficient fossil information to permit the determination of formations or even groups of the Chester series. Guide fossils used in establishing formation boundaries in the region of the Standard Chester section have been rarely observed in cores, and the fossil fragments found in the cuttings are too badly damaged to permit positive identification. With the drilling of additional wells and with the compiling of additional data from future cores of Chester formations there will undoubtedly be better delineation of groups and formations within the Chester series. Geologists of the U. S. G. S. are now making detailed studies of the fossils found in cores of Warrior Basin wells, and it is hoped that the results of their work will aid in defining the group and formation boundaries within the Chester.

Formation Gradation

Part of the difficulty of making precise correlations of the subsurface Chester section with the standard section and with the Alabama surface section is because of the rapid lateral gradation of well developed sandstones into shales and limestones. In Fig. 8 the thick Abernethy sand section of the Justiss-Mears No. 1 Clark is completely absent in the Union No. 1 Dinsmore which is only eight miles from the No. 1 Clark. In Fig. 9 the sands of the Mississipipan of the Carter No. 1 Abernethy grade into limes in the Superior No. 1 Moss-McCormack. These gradations make it difficult to correlate wells, and they are evidence of the absence of sheet sands in the Warrior Basin. Although an absence of sheet sands may not adversely affect the accumulation of oil and gas in the Basin it does make the search for oil traps more difficult.

Porosity and Permeability

In addition to the loss of potential oil and gas reservoirs because of lateral gradations of lithology in the Warrior Basin there is a loss of reservoirs

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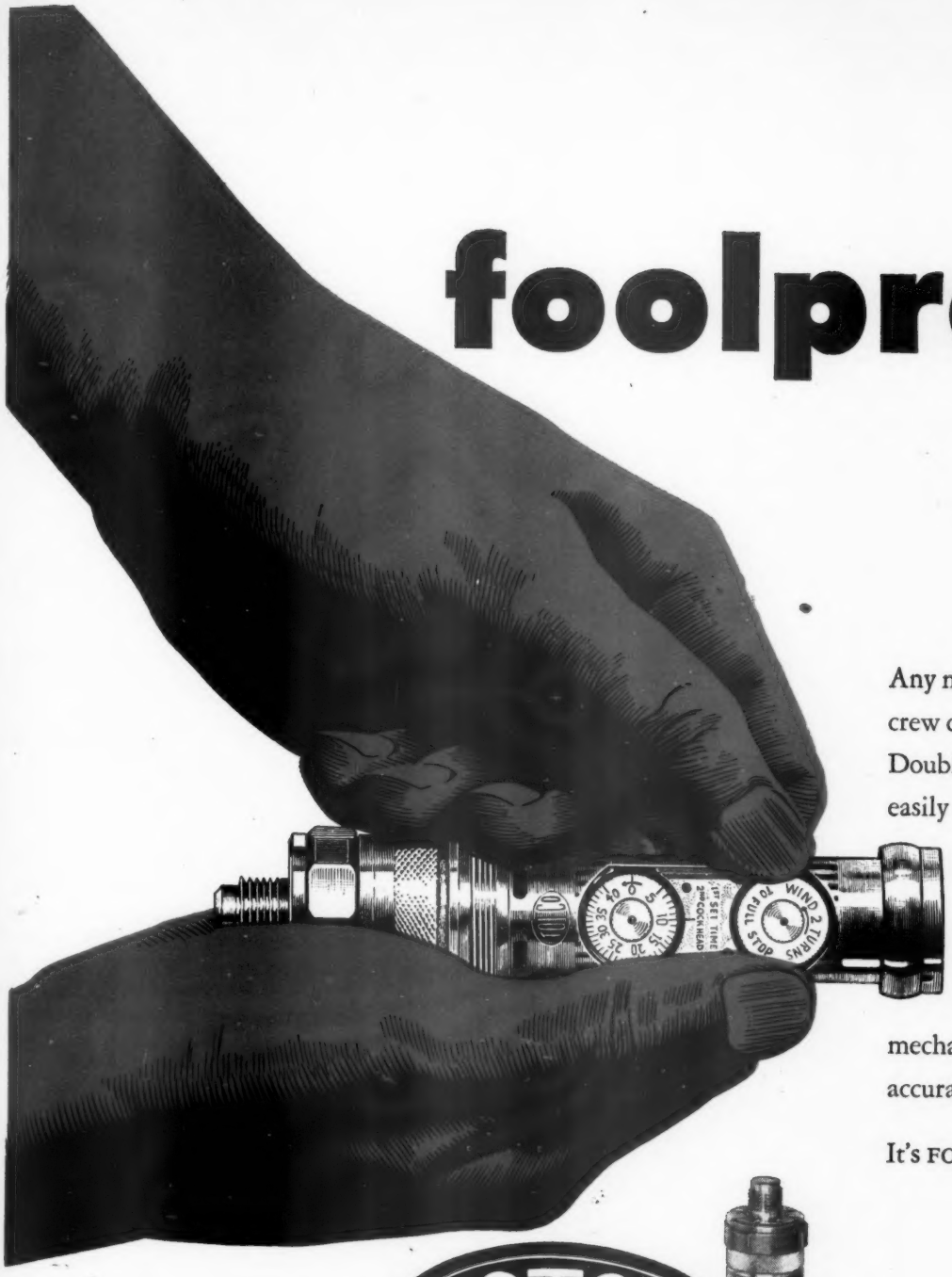

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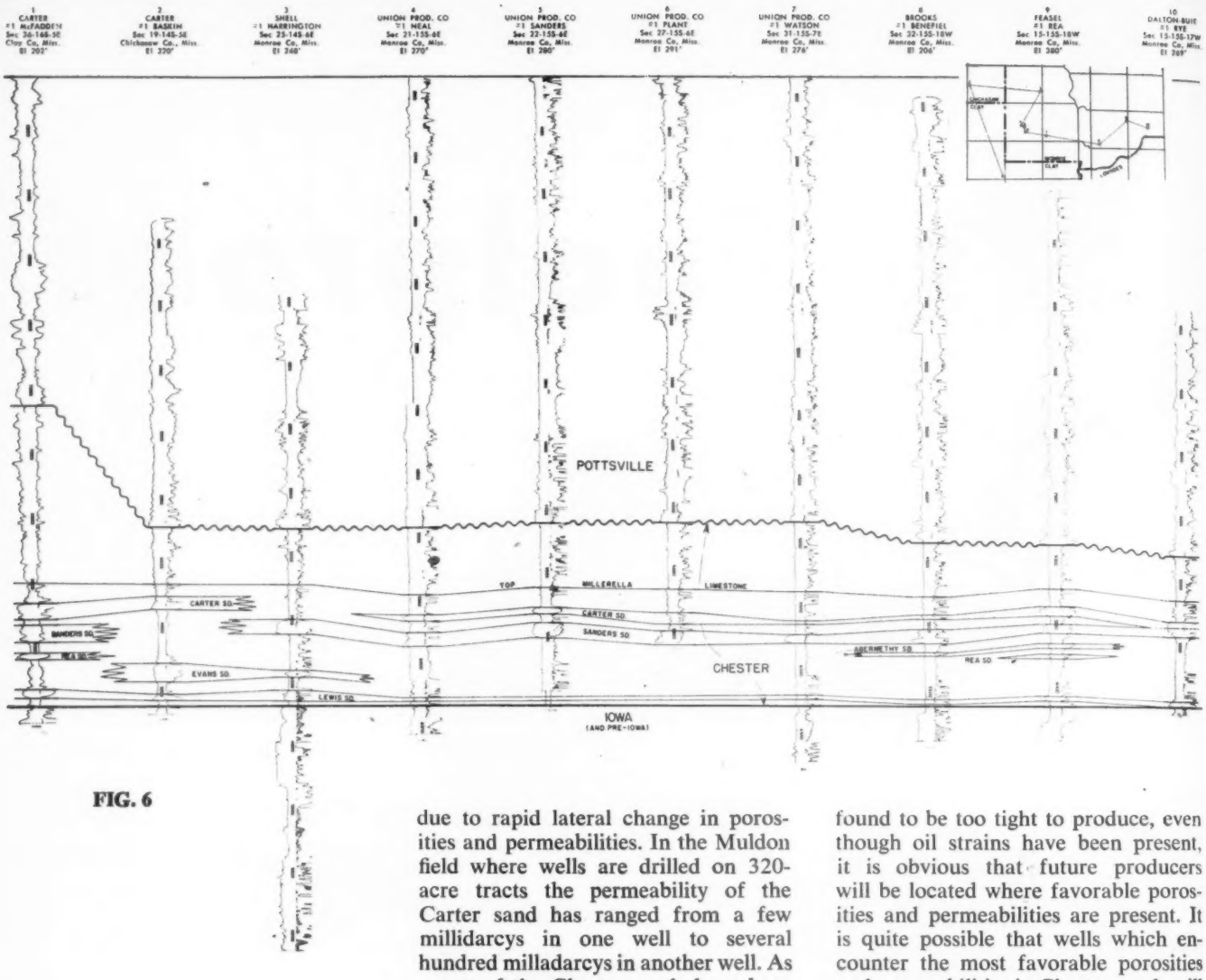

FIG. 6

due to rapid lateral change in porosities and permeabilities. In the Muldon field where wells are drilled on 320-acre tracts the permeability of the Carter sand has ranged from a few millidarcys in one well to several hundred milladarcys in another well. As many of the Chester sands have been found to be too tight to produce, even though oil strains have been present, it is obvious that future producers will be located where favorable porosities and permeabilities are present. It is quite possible that wells which encounter the most favorable porosities and permeabilities in Chester sands will

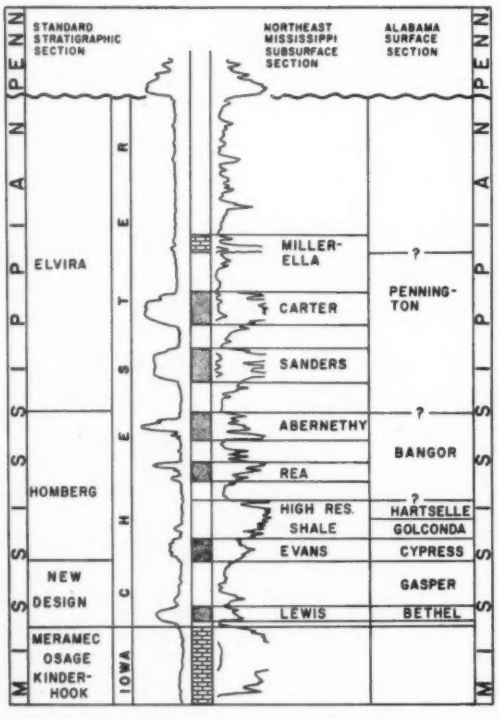

FIG. 7. Composite Warrior Basin electric log.

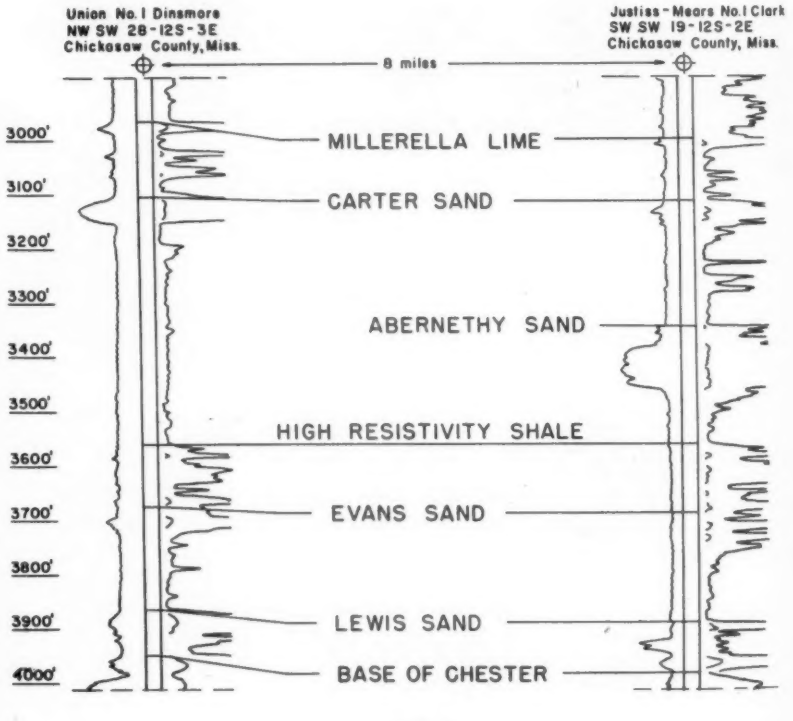

FIG. 8.

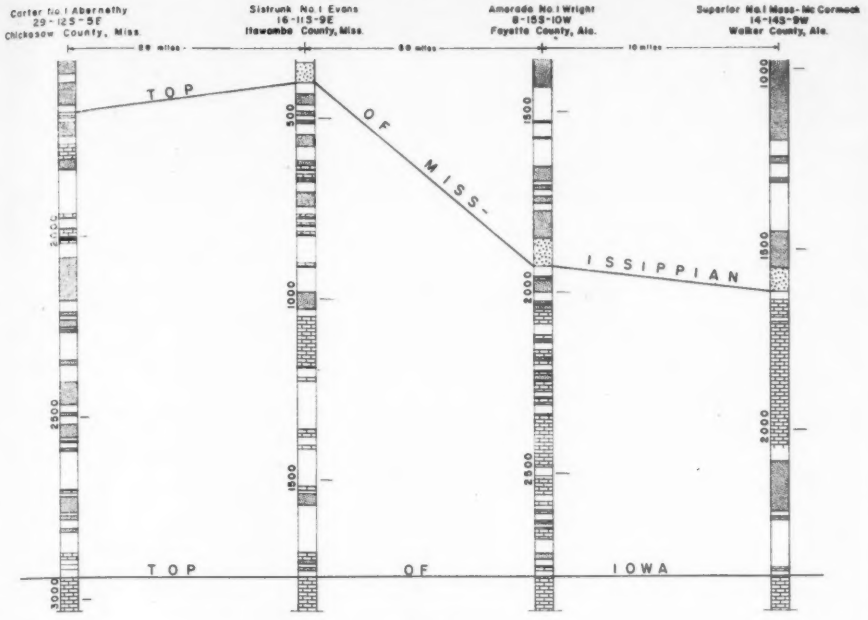

FIG. 9

not be located on the highest parts of the producing structures.

Reservoir Content

Up to the present time no commercial oil production has been found in Chester sands of the Warrior Basin. Many cores of Chester sands have been heavily oil strained, but the only liquid hydrocarbons yet produced have been as condensate along with the gas. As all the presently producing gas fields are on closed structures, it is possible that oil will be found on the flanks of the structures as the fields are developed.

Commercial Formations

Chester sands and limes at the outcrops in several places in the Warrior Basin contain asphalt, and it is undoubtedly because of these oil seeps that a number of the wildcat wells were drilled in the Basin in the early part of the century. Many of the wells in the Warrior Basin have asphaltic shows of oil in Chester sands, but it was not until the Union No. 1 Sanders was completed as a commercial gas well that it was learned that these sands could produce large gas volumes. Following the completion of the No. 1 Sanders, operators began making open hole drillstem tests of all sands with asphaltic shows, but none of the tests yielded gas volumes equal to the No. 1 Sanders calculated open flow of 35,000,000 cu ft per day. One well, however, Carter No. 1 Baskin Heirs (Fig. 6), was completed for a calculated open flow of 36,000,000 cu ft per day after a fracture treatment of the sand that had previously flowed gas at the rate of 150,000 cu ft per day.

Subsequent efforts in other wells to increase gas production by hydraulic stimulation of tight sands indicate that some of the Chester sands with asphaltic shows are too tight to produce oil in commercial quantities in spite of fracture treatments. Therefore, it will be necessary to continue to core and drillstem test Chester sands in wildcats in order to obtain additional information about the fluid content of the reservoirs. Based on this additional information operators will be better able to distinguish between commercial and non-commercial shows of oil and gas.

Conclusions

None of the new gas fields in the Warrior Basin have yet produced sufficient quantities of gas to permit accurate ultimate recovery predictions based on decline curves. As there will be a demand for gas in the Warrior Basin, high prices will probably be paid for the gas; these high prices will tend to offset the high drilling costs for penetrating hard Paleozoic rocks. Costs in drilling will continue to decline as operators gain more experience in improving the rates of penetrating the hard, quartzitic sandstones of the Pennsylvanian and Mississipipan formations. The discovery ratio will continue to be high in the Basin, but the wildcat drilling rate will depend upon the factors of ultimate recovery, drilling costs, and price of gas.

Acknowledgments

The writer wishes to thank the Carter Oil Company for permission to publish this article and the members of the staff of the Jackson office of Carter for their help in preparing this article. Appreciation is expressed to the Mississippi Geological Society for permission to reproduce the cross sections shown in Figs. 4, 5, 6. * * *

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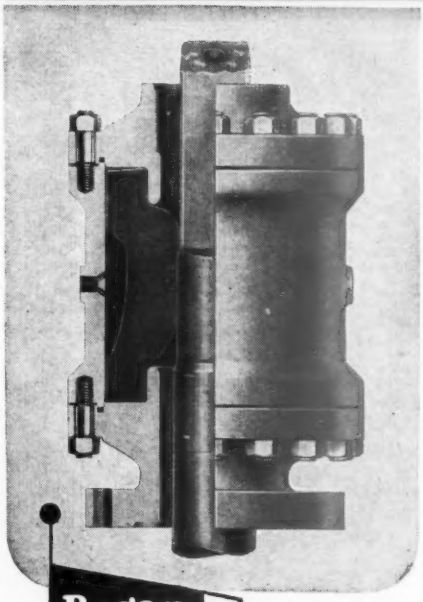

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Above, arrangement of tubing racks at start of installation of Honolulu's 5-string, dual zone hydraulic pump in West Texas. Right, start of installation, supervised by Honolulu Superintendent Burt Guerry (man next to sealing nipple). 250 ft of 2-in. tubing is hanging in slips and 25 ft. of 1-in. CW pipe has been run inside it. The 1-in. runs through the sealing nipple and is tied to crossover shoe (near top of photo). The sealing nipple was then threaded in the 2-in. tubing and the crossover shoe was lowered in the well.

P 514.7

Unusual Two-Zone Pumping Installation

Five strings of tubing run to give independent control of separate pumps and separate relief of gas from each zone

J. B. STUMM*

ON a chilly day in February of this year representatives from most major oil companies gathered around a well in the Prentice field, West Texas, to witness the installation of an unusual well tubing arrangement. They saw three strings of tubing — two 2-in. and one ¾-in. — being run simultaneously into the well bore, and when these were landed they saw a string of ¾-in. tubing lowered into each of the 2-in. strings.

This running of five strings of tubing in a single well bore went off without a hitch and, when all strings were landed and buttoned up, the operator had a two-zone pumping installation with the following characteristics:

1. The pump for each zone is independently operated and controlled.
2. There is no commingling of gas or oil from the two zones.
3. There is a separate gas vent for each zone, even the lower one, which means that neither pump needs to handle free gas.

That the installation was successful is extremely important to the oil industry because it marks the first practical solution to most pumping problems posed by dually completed wells.

The installation was designed and run by Honolulu Oil Corporation. They were faced with the problem of developing and producing the Prentice field, which has two undersaturated limestone pays, the Glorietta at a depth of approximately 6000 ft and the Clearfork at 6700 ft. Under the circumstances it was obviously desirable to produce both zones through dually completed wells if a means could be devised of pumping each zone independently without communication, as prescribed by the Oil and Gas Division of the Texas Railroad Commission. The successful solution of the problem included the running of five strings of tubing as described above.

EXCLUSIVE

Installation Design

In considering the problem, Honolulu Oil Corporation felt that the best method of pumping the two-zones would be by the conventional hydraulic system, in which the bottom hole hydraulic pumping unit is run to bottom on small tubing. A major consideration in this decision was the fact that obviously the space at the wellhead would be limited to such an extent as would prohibit two separate beam pumping units. A second important consideration in selecting the hydraulic system was the fact that in running multiple strings it would be highly desirable, if not essential, to eliminate any tendency of alternate stressing of the strings, which might break the clamps required to hold them.

With this decision made, it was then

*Editor, Pacific Coast.

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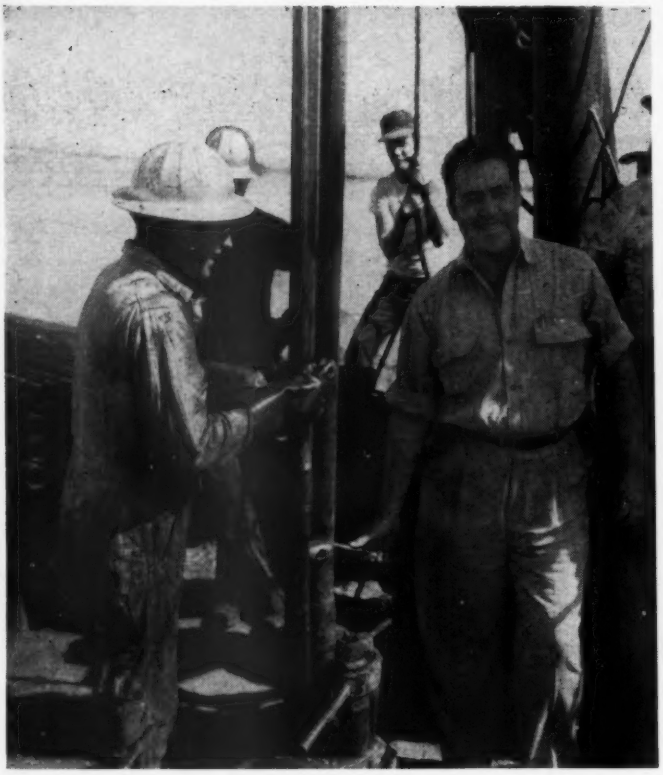


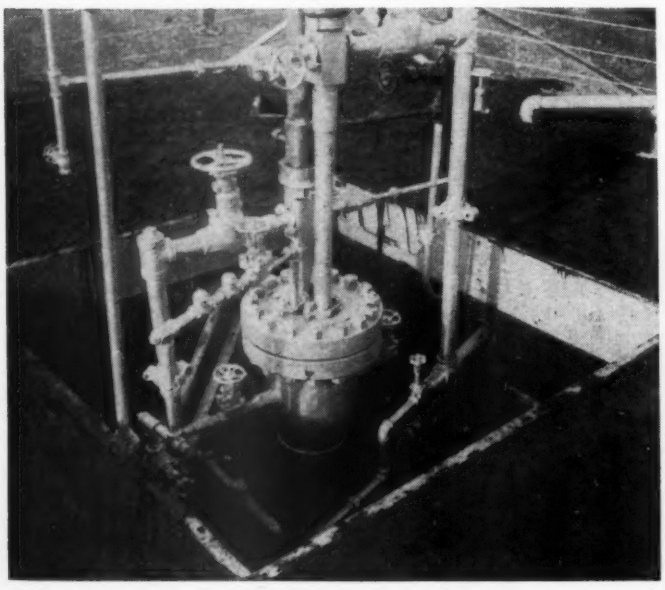
Special 2-in. x 2-in. clamps held two 2-in. strings together. These were spaced just above upset of each joint of the N-80 string. Man at right of tubing is F. C. Edwards, Honolulu's Division Engineer, who is largely responsible for design of the installation. Right, making up ¾-in. string (which relieves gas from beneath the packer) prior to lowering crossover shoe through spider.

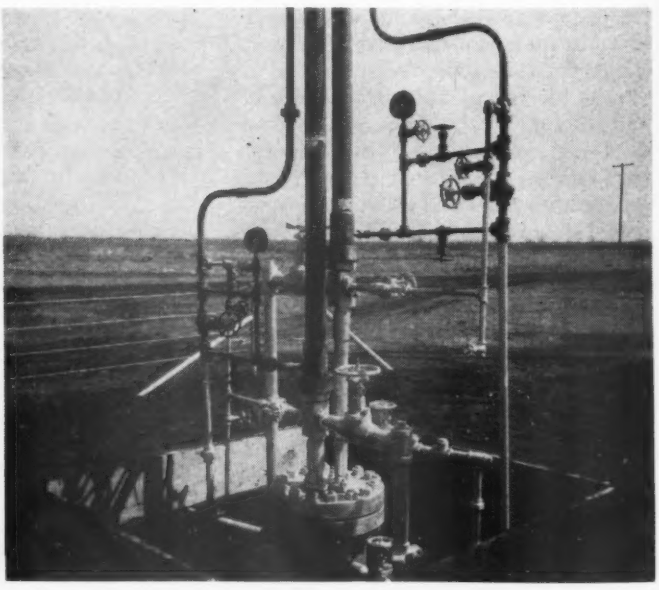
indicated that two strings of production tubing would be required in the well, one for each of the hydraulic pumps installed for pumping the two zones. Further investigation revealed it would be practical to run a third small string beside the two 2-in. strings and use the small string as a vent for producing free gas from the lower zone. The decision was made to install a single retainer production packer just above the top of the lower zone and to have no packer above the upper zone. Thus free gas produced from the lower zone is produced through the packer and conducted to the surface through a small tubing string.

An analysis of the strength characteristics of the tubing indicated that the entire bundle of tubing could be carried by a 2-in. string of N-80 tubing. Accordingly one string of N-80 tubing was installed and the other was J-55 grade. Both of these were external upset. The small gas string was ¾-in. CW.

The casing program of the well called for 9⅝-in. OD to approximately 2400 ft and a 7-in. liner run and set just above the lower producing zone. The lower zone is, therefore, open hole, and the upper zone is producing through perforations. The retainer production packer is set approximately 200 ft above the lower producing zone.

A special fluid crossover shoe was fabricated for the installation, and this





Cellar of completed wellhead showing manner of completion. Right, in landing, the 2-in. tubing strings were spaced as shown here to provide offset for hydraulic lifts (used to scrape paraffin in the annulus between power oil and production tubing strings).

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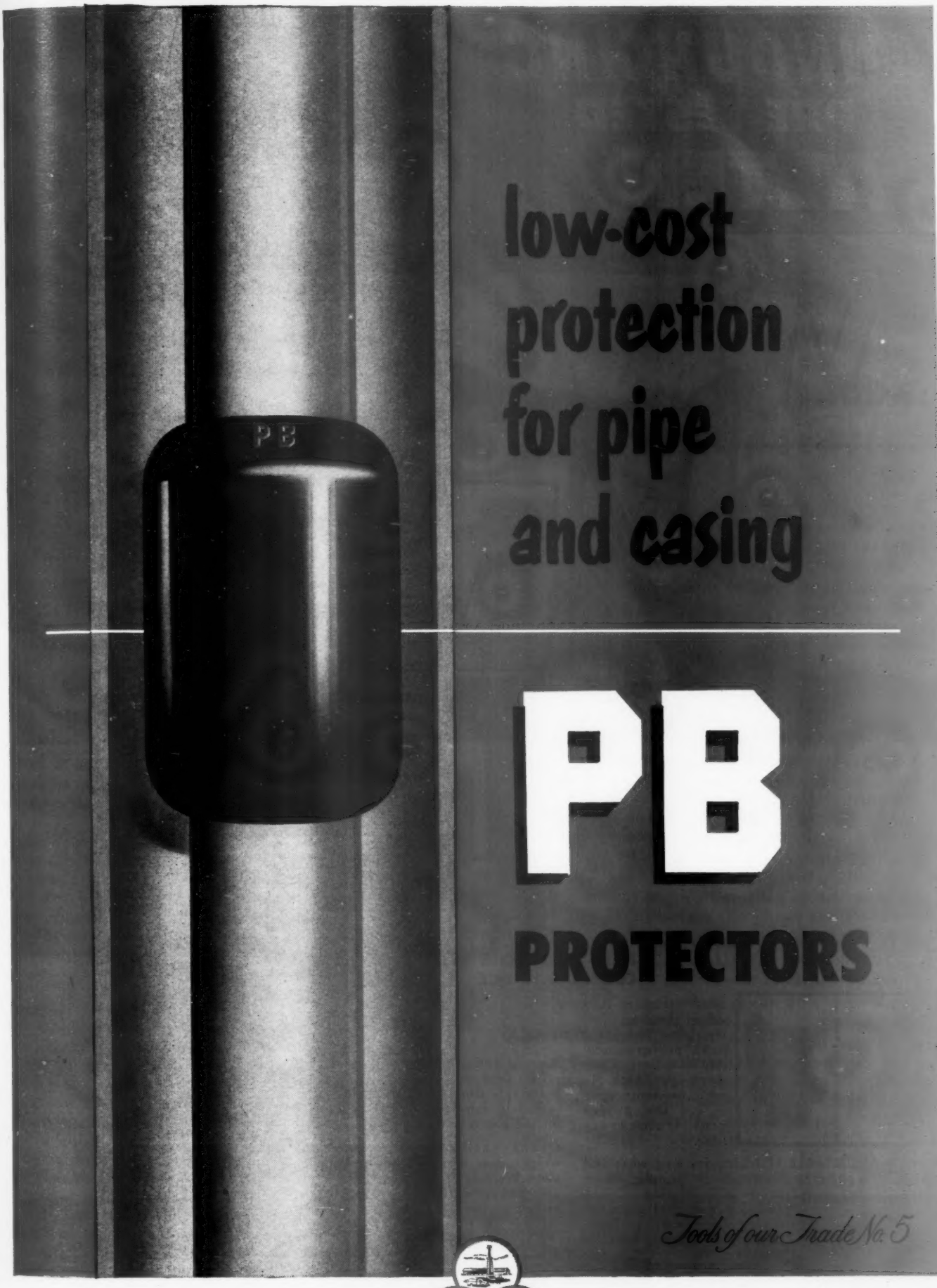

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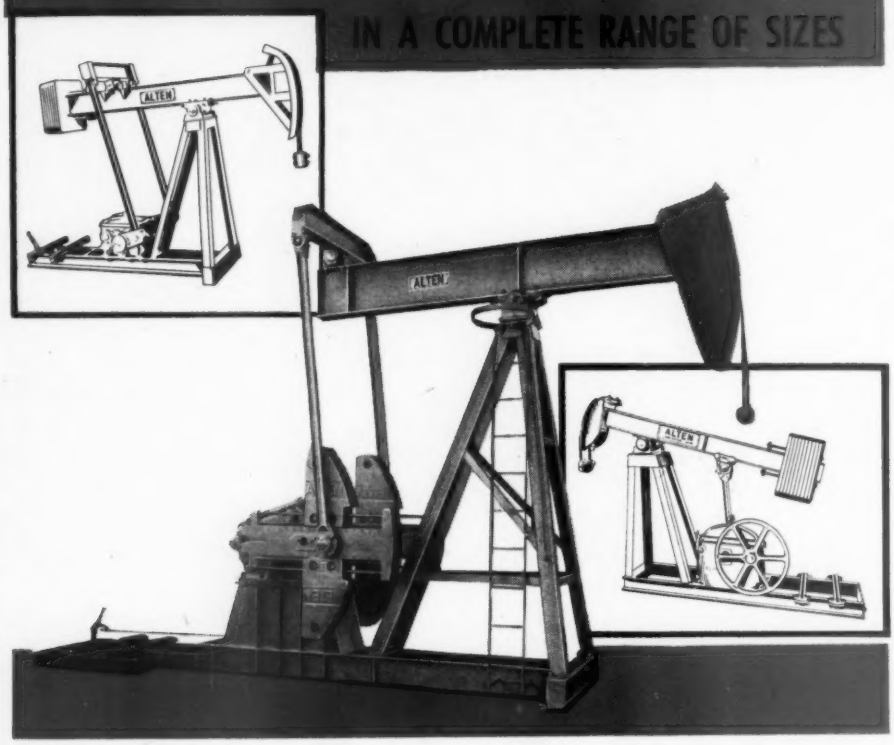

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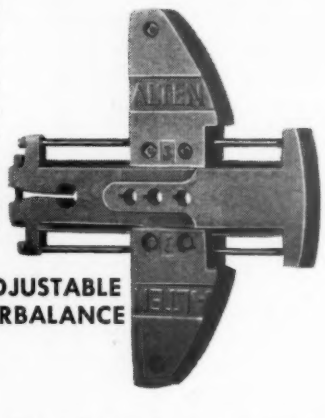

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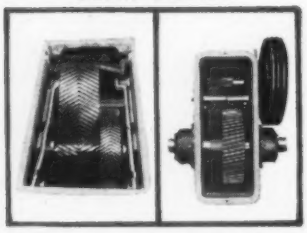

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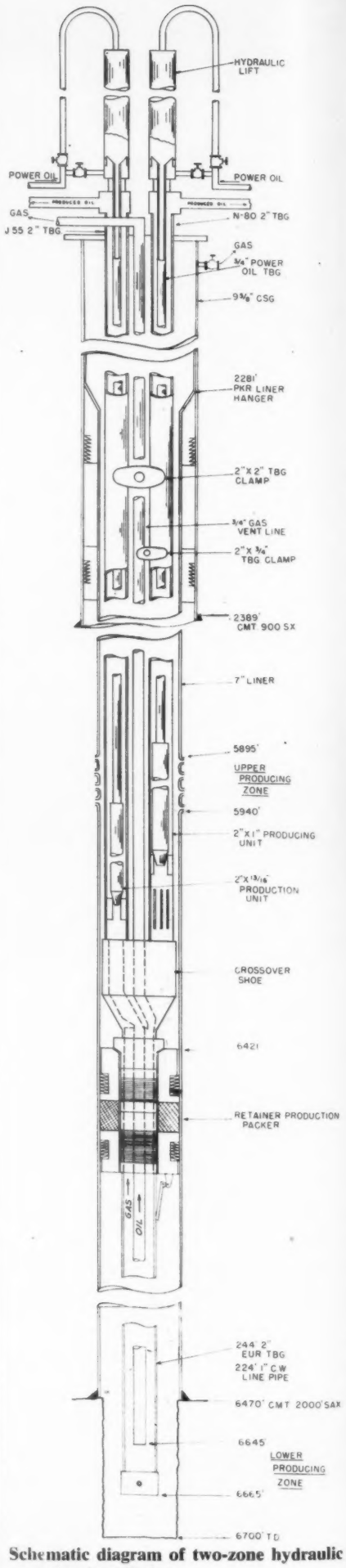
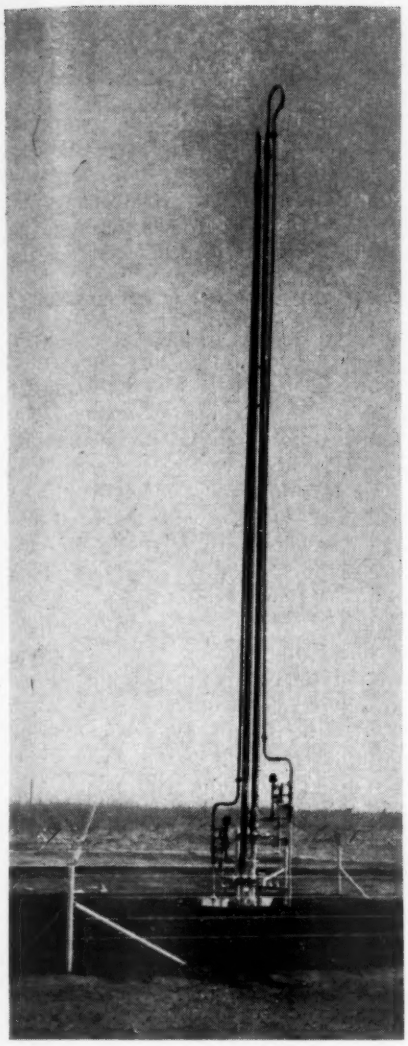


Schematic diagram of two-zone hydraulic pumping installation.



View of one of five dual zone hydraulic pumping installations completed by Honolulu in the Prentice Field.

shoe provided a mechanical connection for the three strings of tubing, as well as a fluid connection for gas and oil from beneath the packer for two of the strings.

The tubinghead was also especially designed for the installation and provides for slip suspension of each of the two 2-in. tubing strings. The ¾-in. gas vent for the lower zone comes through a simple packing gland and is not suspended by the head. Special 2-in. by 2-in. tubing clamps were ordered for the job, and these were used to hold the two 2-in. strings together. A conventional 2-in. by ¾-in. clamp was used to hold the ¾-in. gas vent string to one 2-in. string.

Because the production of both zones cause paraffin problems common in West Texas fields, there is installed on each of the 2-in. tubing strings a hydraulic lift, which is used to scrape paraffin in the annulus between the production tubing and the small macaroni tubing on which the bottom-hole hydraulic pump is run. As is shown in accompanying photographs, the base of

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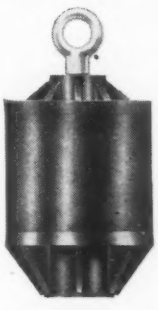
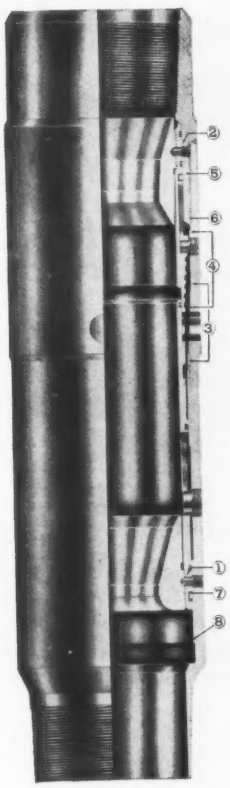


Bottom plug with eye hook

Weighted Trip Ball



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these lifts are spaced approximately 18 in. apart to provide the room required for the installation.

Running of Equipment

The first tubing run in the well was approximately 250 ft of 2-in. which serves as a tail pipe below the packer. With it suspended in the slips approximately 225 ft of 1-in. tubing was run inside to serve as a stinger. The 1-in. was run through the sealing nipple and threaded into the crossover shoe, which provided a fluid intake from the 1-in. to the intake of one of the 2-in. pumps. The 2-in. tail pipe was then threaded into the sealing nipple, which in turn was threaded to a locator sub, and into that was threaded the crossover shoe. This arrangement tied the annulus between the 1-in. stinger and the 2-in. tail pipe to the ¾-in. gas vent line above the fluid crossover.

Out of the top of the fluid crossover shoe there came the ¾-in. gas vent line and two 2-in. tubing strings. One 2-in. string that serves for pumping the lower zone contains a seat for the hydraulic production unit. The other 2-in. string has a 6-ft perforated sub joint and then a seat for the hydraulic production unit. This string serves to produce the upper zone through perforations in the 2-in. sub.

As the strings were run, both 2-in. tubing strings were hydro-tested to 5000 psi. After being hydro-tested they were also drifted.

For running the 3 strings, a special tubing spider was employed. This permitted the insertion of slips almost completely around the N-80 string, and yet provided a side door large enough to accommodate the other 2-in. and the ¾-in. string.

Just above each joint of N-80 tubing there is installed a 2-in. by 2-in. clamp attached to the other 2-in. string. Approximately half way between the 2-in. by 2-in. clamps a 2-in. by ¾-in. clamp is installed to tie the ¾-in. string to the 2-in. N-80.

As previously described, the tubing strings were landed with a special tubinghead, which provided for slip suspension of each of the two 2-in. tubing strings and with a simple packing gland for the ¾-in. string. Part of the weight of the string was, of course, transferred to the retainer production packer before the landing slips were set.

After the 3 strings were landed, the hydraulic production units were run, each on ¾-in. tubing within each 2-in. tubing string. This operation was routine and no problem was encountered. After both pumps were landed, hydraulic lifts were installed on each 2-in. tubing string as previously described, and both zones were put on the pump.

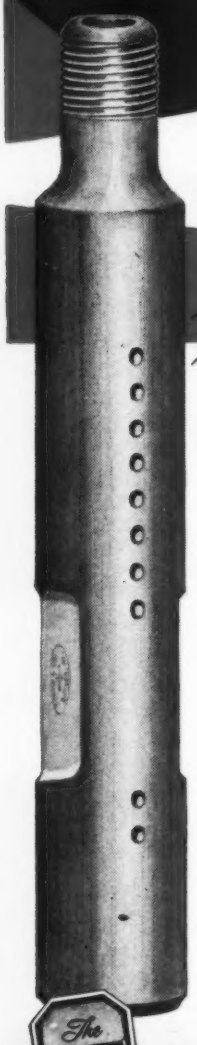
Performance

Honolulu's management is closely watching the performance of this two-zone pumping installation. In toting up relative costs, there is a clear-cut savings of $50,000 per well in drilling and equipping 1 two-zone well as opposed to drilling and equipping 2 single zone wells. As can be imagined, this savings is enough to assure payout if the dual zone pumping installation is successful.

To date, there is every indication that both pump operation and well maintenance of the dual zone installation are as simple, practical, and economical as they would be in hydraulically pumping individual single-zone wells. These indications are based upon observation of 8 dual-zone wells completed since February combined with an extrapolation of the company's experience with hydraulic pumping in more than 200 single-zone wells in other West Texas fields.

Summary

Honolulu's dual zone pumping installation offers a major savings in development costs and, at the same time, it gives promise of providing for the operation of two pumps in a single well as simply and economically as if the pumps were in separate wells. * * *

FOR MAXIMUM STRENGTH and SERVICE
SPANG
Prosser-Type
Swivel Rope Sockets


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Completely Heat-Treated for uniform toughness and hardness inside and out, SPANG Prosser-Type Rope Sockets give longer service, greater footage at lower cost.
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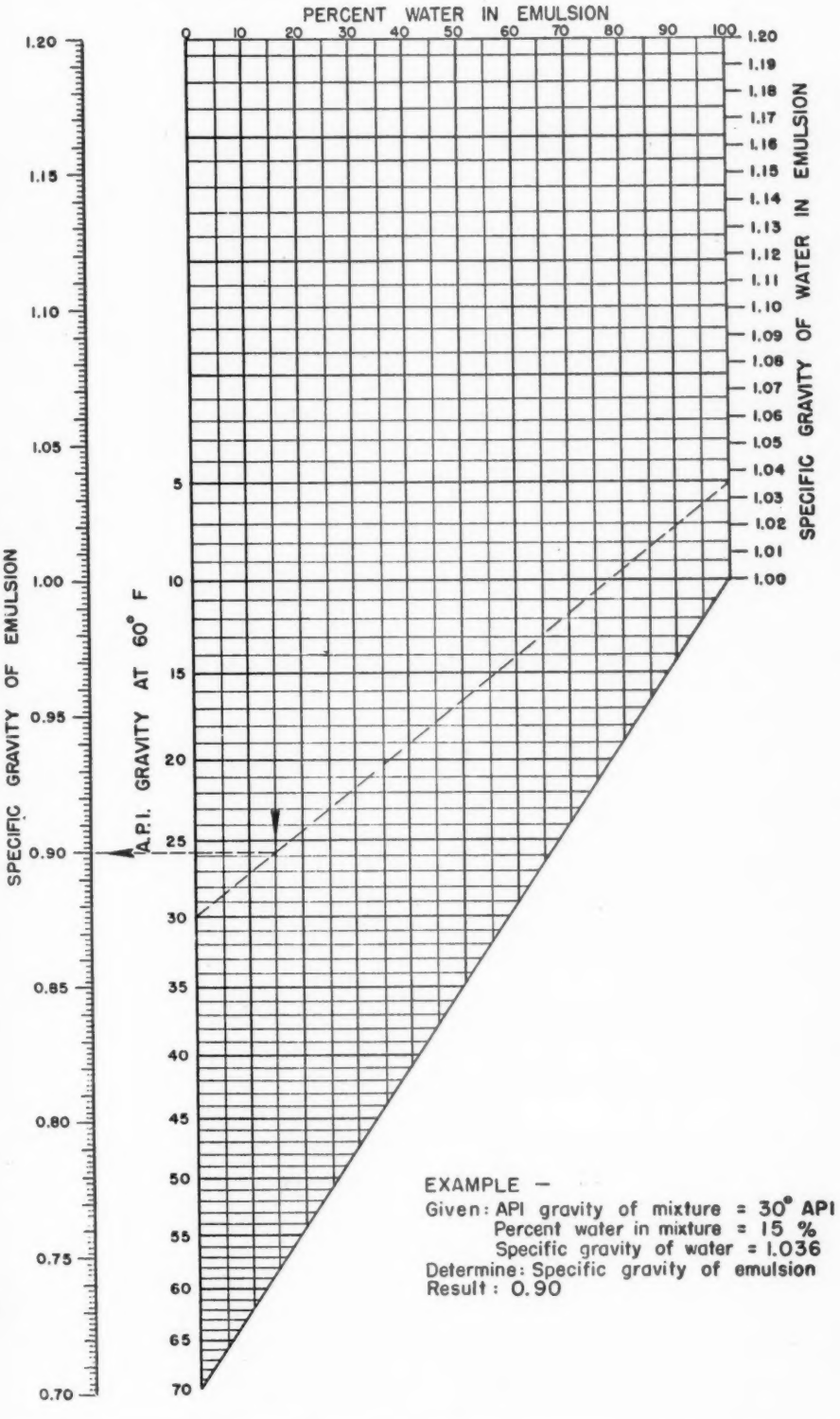
Manual for Selection of Beam Pumping Equipment

HOWARD L. KELLEY and ROY M. WILLIS

FIG. 12. CHART FOR FINDING API GRAVITY AND SPECIFIC GRAVITY OF OIL AND WATER MIXTURES.


PERCENT WATER IN EMULSION
0 10 20 30 40 50 60 70 80 90 100
SPECIFIC GRAVITY OF EMULSION
1.20 1.15 1.10 1.05 1.00 0.95 0.90 0.85 0.80 0.75 0.70
A.P.I. GRAVITY AT 60° F
5 10 15 20 25 30 35 40 45 50 55 60 65 70
SPECIFIC GRAVITY OF WATER IN EMULSION
1.20 1.19 1.18 1.17 1.16 1.15 1.14 1.13 1.12 1.11 1.10 1.09 1.08 1.07 1.06 1.05 1.04 1.03 1.02 1.01 1.00
EXAMPLE —
Given: API gravity of mixture = 30° API
Percent water in mixture = 15 %
Specific gravity of water = 1.036
Determine: Specific gravity of emulsion
Result: 0.90

BELOW are continued the steps to follow in making selection of equipment for beam pumping installation:

28. Add hydraulic horsepower (26) to friction horsepower (27) to obtain estimated polished rod horsepower.

29. Multiply the polished rod horsepower (28) by a factor of 1.5 to obtain required brake horsepower. Select an internal combustion engine of the proper size from the 65 per cent API hp curve for multi cylinder engines and the 75 per cent maximum horsepower curves for single cylinder engines. Select an electric motor of the proper size by comparing the brake horsepower requirements with the nameplate ratings shown on Fig. 23 which have been reduced 25 per cent and designated as "Usable Brake Horsepower." The nameplate ratings have been reduced to account for the horsepower capacity, which is lost because of motor heating caused by cyclic loads.

30. With the speed of the selected engine in rpm, the unit sheave and gear ratio from the manufacturers' specification, determine engine sheave size from Fig. 24 which is based on the following formula: (See next page.)

FIG. 13. PER CENT OF EACH SIZE ROD IN TAPERED ROD STRINGS.

Plunger size—inches	Rod combinations					
	1	⅞	¾	⅞	¾	⅝
1	17.22	19.68	63.19	20.67	23.18	56.15
1 1/16	17.64	20.17	62.19	21.33	23.94	54.73
1¼	19.07	21.80	59.13	23.56	26.43	50.01
1½	21.33	24.39	54.28	27.10	30.39	42.51
1¾	24.01	27.44	48.55	31.28	35.08	33.64
1½ x 1½	25.45	29.09	45.46	33.54	37.61	28.85
2	27.09	30.97	41.94	36.10	40.48	23.42
2¼	30.59	34.97	34.44	41.56	46.61	11.83
2½	34.50	39.48	26.02	—	—	—
2 x 2	35.46	40.57	23.97	—	—	—
2¾	38.82	44.38	16.80	—	—	—
3¾	—	—	—	—	—	—
4¾	—	—	—	—	—	—

Plunger size—inches	Rod combinations					
	1 x ⅞		⅞ x ¾		¾ x ⅝	
1	19.51	80.49	23.32	76.68	28.11	71.89
1 1/16	19.90	80.10	23.90	76.10	29.01	70.99
1¼	21.18	78.82	25.84	74.16	32.05	67.95
1½	23.22	76.78	28.91	71.09	36.85	63.15
1¾	25.63	74.37	32.54	67.46	42.53	57.47
1½ x 1½	26.93	73.07	34.50	65.50	45.60	54.40
2	28.41	71.59	36.73	63.27	49.09	50.91
2¼	31.56	68.44	41.48	58.52	56.52	43.48
2½	35.08	64.92	46.79	53.21	64.83	35.17
2 x 2	35.95	64.05	48.09	51.91	66.87	33.13
2¾	38.98	61.02	52.65	47.35	74.00	26.00
3¾	58.25	41.75	81.69	18.31	—	—
4¾	83.33	16.67	—	—	—	—

Rod cross sectional areas					
Rod size.....	1⅛"	1"	⅞"	¾"	⅝"
Cross sectional area	0.9940	0.7854	0.6013	0.4417	0.3068

$$\text{Engine sheave} = \frac{(\text{unit sheave})\ (\text{pumping speed-spm})\ (\text{gear ratio})^*}{(\text{engine speed-rpm})}$$

*When the material used in this paper is used to check equipment already installed on operating wells to determine if they are of the proper size and operating under the correct conditions, it will be found that many of the steps listed in the above instructions can be omitted due to the knowledge that will exist of some of the conditions that would otherwise need to be calculated or assumed.

APPENDIX

Variables, Parameters, and Concepts

Selection curves in this manual do not differentiate in the type of well being produced and have been developed on the basis of total fluid desired from a given pump setting depth. It is believed that field engineers, based on their experience in a particular area, can select equipment by using these curves and then adjust the size of the equipment up or down in accordance with known specific conditions.

To acquaint personnel using this manual with the variables, parameters, limitations, and general concepts used in the development of the selection curves, they are discussed below together with a brief explanation of the calculation and selection methods. This discussion will follow the sequence used on data sheet No. 2 which is used to tabulate the individual calculations.

Operating Cycle

Pumping Speed. The maximum practical limit for pumping speed is that speed at which the rods fail to fall freely on the downstroke. As indicated in Fig. 10, this usually occurs at approximately 70 per cent of the maximum free fall limit. At higher speeds the polished rod clamp could be expected to leave the hanger bar on the downstroke. In those instances where high pumping speeds are required and the sucker rod loads are not critical the limits outlined by Fig. 10 are acceptable.

For the purpose of this manual, however, Fig. 11 (pumping speed selection chart) was derived for the selection of a maximum pumping speed. This chart was based on dynamometer data on 81 individual wells in 8 districts. In conjunction with this chart the maximum pumping speed has been defiined as being that speed at which the maximum rod load due to overtravel will not exceed the maximum rod load required to lift the well. Adoption of this speed as a maximum may be somewhat conservative but it does insure that unnecessary high rod loads will not be encountered because of overtravel.

Considerable data have been presented in the past regarding synchronous speeds which are in phase with the harmonic vibration of the natural frequency of the sucker rod string as indicated by the formula—

$$\text{Natural frequency of rod string} = \frac{237{,}000}{L}$$

Where L = Length of rod string in feet.

Pumping speeds to be in phase with these frequencies would be equal to the frequency for the first order, one-half the frequency for second order, one-third the frequency for third order, etc.

Some operators have been of the opinion that synchronous speeds should be avoided for good sucker rod life. Actually many pumping wells have operated at synchronous speeds over long periods of time without any detrimental effect or abnormal rod breakage. Limitations due to synchronous speeds have not been considered in this manual since operating data have failed to give any correlation between operation at calculated synchronous speeds and actual rod breakage or dynamometer test results.

Polished Rod Stroke Length. As a general rule, the operating cycle (Both strokes per minute and length of stroke) changes as the pump setting depth changes. Fig. 1 shows that for a given amount of fluid that as the lift depth increases, the size pumping unit required also increases. With an increase in the size of the pumping unit, a longer stroke automatically becomes available. For a given unit when an option in stroke length is available, it is desirable to use the longest stroke available. This tends to reduce the rod loads while at the same time gives higher pump displacements. Because several of the pumping unit manufacturers make units with a choice of maximum stroke length in several of the API sizes, selection curves have been prepared for the 114, 160, 228, and 320 API size units showing two different stroke lengths.

Subsurface Pumps

General. In the construction of the displacement curves for the individual

FIG. 14. TABLE FOR CALCULATING WELL LOADS.

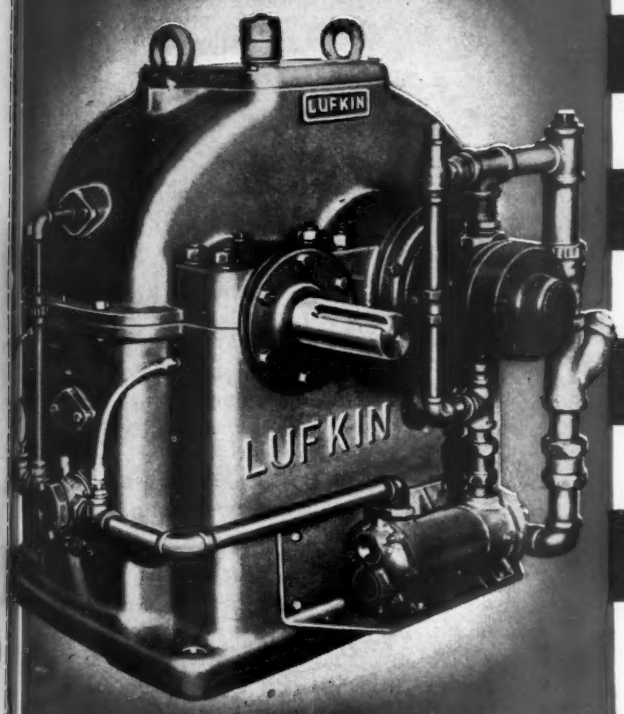
Rod combinations	Plunger diameters 1	1 1/16	1 1/4	1 1/2	1 3/4	1 1/2x1 1/2	2	2 1/4	2 1/2	2x2	2 3/4	3 3/4	4 3/4
A. Rod loads (lb/ft)													
5/8	1.18	1.18	1.18	1.18	1.18	1.18	—	—	—	—	—	—	—
3/4—5/8	1.309	1.314	1.328	1.349	1.375	1.390	—	—	—	—	—	—	—
3/4	1.64	1.64	1.64	1.64	1.64	1 64	1.64	1.64	1.64	1.64	—	—	—
7/8—3/4—5/8	1.498	1 508	1.541	1.596	1.660	1.695	—	—	—	—	—	—	—
7/8—3/4	1.771	1.774	1.784	1.802	1.822	1.834	1.846	1.873	1.902	1.908	1.935	—	—
7/8	2 20	2.22	2 20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
1—7/8—3/4	1 965	1.972	1.999	2.041	2.091	2 102	2.149	2.215	2.290	2.307	2.370	—	—
1—7/8	2.333	2.335	2.732	2.358	2.374	2.383	2.393	2.415	2 438	2.445	2 465	2.596	2.767
1	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88
B. Fluid loads (lb/ft) SP. BR. of 1.0													
5/8	0.207	0.251	0.402	0.633	0.909	1.055	—	—	—	—	—	—	—
3/4—5/8	0.191	0.234	0.383	0.612	0.884	1.030	—	—	—	—	—	—	—
3/4	0.149	0.193	0.344	0.574	0.851	0.997	1.228	1.531	1.936	2.027	2.382	—	—
7/8—3/4—5/8	0.168	0.209	0.357	0.580	0.850	0.990	—	—	—	—	—	—	—
7/8—3/4	0.133	0.177	0.326	0.554	0.828	0.973	1.144	1.502	1.904	1.994	2.346	—	—
7/8	0.080	0.124	0.275	0.505	0.782	0.927	1.101	1.462	1.867	1.958	2.313	4.525	7.418
1—7/8—3/4	0.110	0.153	0.300	0.526	0.797	0 939	1.109	1.461	1.858	1 946	2.294	—	—
1—7/8	0.064	0.108	0.258	0.487	0.762	0.905	1.078	1.437	1.839	1.929	2.281	4.478	7.352
1	0.000	0.044	0.195	0 425	0.702	0.848	1.021	1.383	1.787	1.878	2.233	4.445	7.338
C. Pump constants, bbl/day / in. of stroke / stroke / min	0 117	0.132	0.182	0.262	0.357	0.408	0.466	0.590	0.728	0.762	0.881	1.64	2.63
D. Peak torque factors	0.30	0.31	0.34	0.36	0.38	0.39	0.40	0.42	0.43	0.43	0 44	0.45	0.45

FIG. 15. MILLS ACCELERATION FACTOR.

Strokes per Minute	Length of polished rod stroke—Inches 24	34	44	48	54	64	74	84	120	144	240	300	360
1	1.000	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.002	1.002	1.003	1.004	1.005
2	1.001	1.002	1.002	1.003	1.003	1.004	1.004	1.005	1.007	1.008	1.014	1.017	1.020
3	1.003	1.004	1.006	1.006	1.007	1.008	1.009	1.011	1.015	1.018	1.031	1.038	1.046
4	1 005	1.008	1.010	1.011	1.012	1.015	1 017	1.019	1.027	1.033	1.054	1.068	1.082
5	1.009	1.012	1.016	1.017	1.019	1.023	1.026	1.030	1.043	1.051	1.085	1.106	1 128
6	1.012	1.017	1.022	1.025	1.028	1.033	1.038	1.043	1.061	1.074	1.128	1.149	1.184
7	1.017	1.024	1.031	1.033	1.038	1.044	1.051	1.058	1.083	1.100	1.167	1.209	1.250
8	1.022	1.031	1.040	1.044	1.049	1.058	1.067	1.076	1.109	1.131	1.218	1.272	1.327
9	1.028	1.039	1.051	1.055	1.062	1.074	1.085	1.097	1.138	1.165	1.276	1 345	1.414
10	1.034	1.048	1.062	1.068	1.077	1.091	1.105	1.119	1.170	1.204	1.340	1.425	
11	1.041	1.058	1.076	1.082	1.093	1.110	1.127	1.144	1.206	1.247	1.412		
12	1.049	1.069	1.090	1.098	1.110	1.131	1.151	1.172	1.245	1.294			
13	1.058	1.081	1.105	1.115	1.129	1.153	1.177	1.201	1.288	1.345			
14	1.067	1.095	1.123	1.134	1.151	1.179	1.207	1.235	1.335	1.402			
15	1.077	1.109	1.141	1.154	1.173	1.205	1.237	1.269	1.385	1.462			
16	1.087	1.124	1.160	1.174	1.196	1.233	1.269	1.305	1.436	1.523			
17	1.098	1.139	1.180	1.197	1.221	1.262	1.303	1.344	1.492				
18	1.110	1.156	1.202	1.221	1.248	1.294	1.340	1.386	1.552				
19	1.123	1.174	1.225	1.246	1.277	1.328	1.379	1.430					
20	1.136	1.193	1.250	1.272	1.306	1.363	1.420	1.477					
21	1.150	1.213	1.275	1.300	1.338	1.400	1.463	1.526					
22	1.165	1.233	1.302	1.330	1.371	1.440	1.508	1.577					
23	1.180	1.255	1.330	1.360	1.405	1.480	1.555	1.630					
24	1.196	1.278	1.360	1.392	1.441	1.523	1.605	1.686					

$$\text{Mills acceleration factor} = 1 + \frac{LN_2}{70{,}500}$$

Lufkin HERRINGBONE GEAR SPEED REDUCERS AND INCREASERS



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ANY RATIO
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ANY JOB

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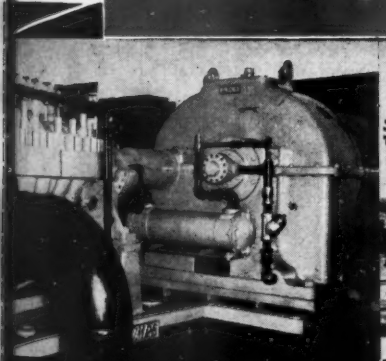
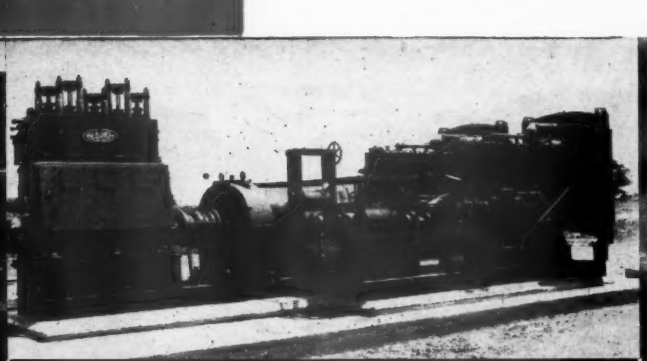
Eighty Different Sizes From Which To Choose



PIPELINE PUMP



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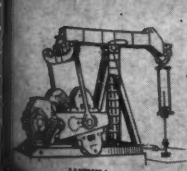
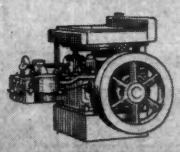
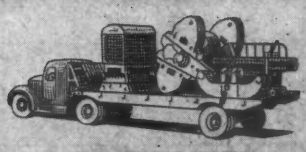


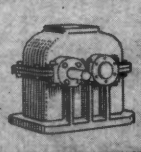
LUFKIN PUMPING UNITS



LUFKIN-COOPER-BESSEMER ENGINES



LUFKIN OIL FIELD AND INDUSTRIAL TRUCK TRAILERS



INDUSTRIAL SPEED REDUCERS AND INCREASERS

DIVISION LUFKIN FOUNDRY & MACHINE COMPANY INDUSTRIAL, MILL AND AUTOMOTIVE SUPPLIES

XUM

pumping units, all pumps were assumed to have a volumetric efficiency of 100 per cent and the next smaller size pump was selected when it could lift as much or more fluid with lower resultant load than the larger size pump.

Pump Efficiency. Pump efficiencies vary considerably because of well conditions, type of fluid being produced, depth of lift, gas interference, pump type, etc. The following tabulation contains some general pump efficiency ranges which may be used as a guide where operating experience is not available.

Efficiency per cent	*Well condition*
25-50	1. Small volume wells which occasionally pump off. 2. Wells which have a gassy or foamy fluid condition.
50-70	1. Deeper wells with a rather low fluid level. 2. Gassy wells with a fair to to good in hole separation of formation gas.
70-80	1. Normal pumping range for a good installation. 2. Indicates good separation if there is any gas and ample pump submergence.
80-100	1. No gas interference. 2. Indicates a high fluid level well with the pump set rather high in the well.

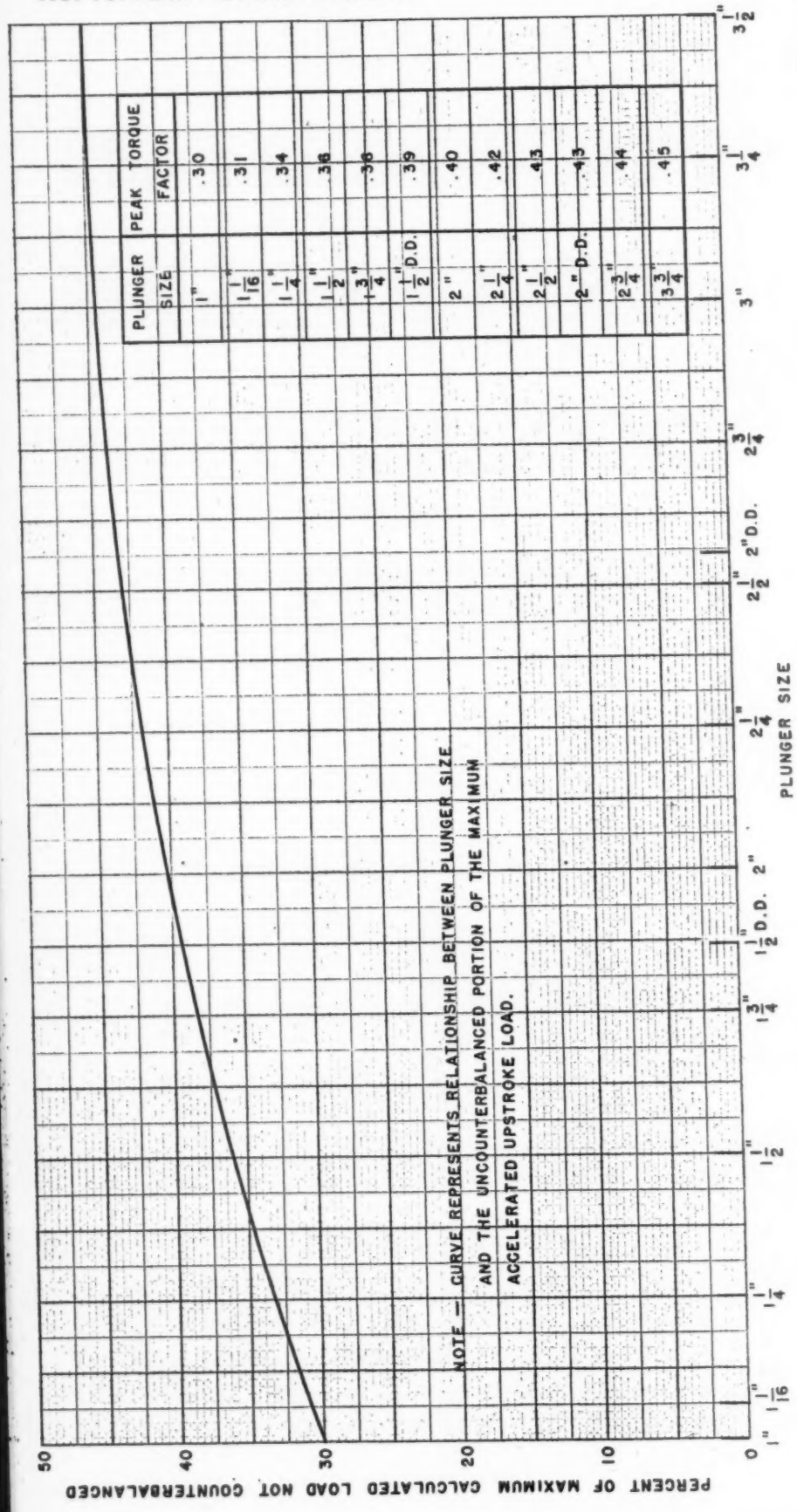
Mechanical Aspects. Basic elements of a subsurface pump are the barrel, plunger, traveling valve, standing valve, and hold-down. Various type pumps can be divided into two general classifications—tubing type (T) and rod type (R). In tubing pumps, the barrel is a component part of the tubing string—the plunger being run on the rod string. Thus the tubing must be pulled to service the entire pump.

Rod type pumps are attached to the sucker rods and when repairing the rod type pump the complete pump can be removed from the well on the sucker rods.

Pumps can be further classified with regard to barrel type. The two general classes of barrels are the full barrel (W) and the liner barrel (L). The full barrel is a one-piece barrel connected directly to the tubing or sucker rods by means of collars. The liner barrel consists of a series of liners suspended in a jacket by collars at both ends which are connected to the tubing or sucker rods.

From the above, it becomes evident that there is a maximum size pump

FIG. 16. PEAK TORQUE FACTORS.



LARGEST PERMISSIBLE PUMPS FOR API TUBING.

Pump type	Tubing size 2 in.	2½ in.	3 in.
Tubing full barrel (TW)	1¾	2¼	2¾
Tubing liner barrel (TL)	1¾	2¼	2¾
Rod full barrel (RW)	1½	2	2½
Rod liner barrel (RL)	1¼	1¾	2¼

No rotation required

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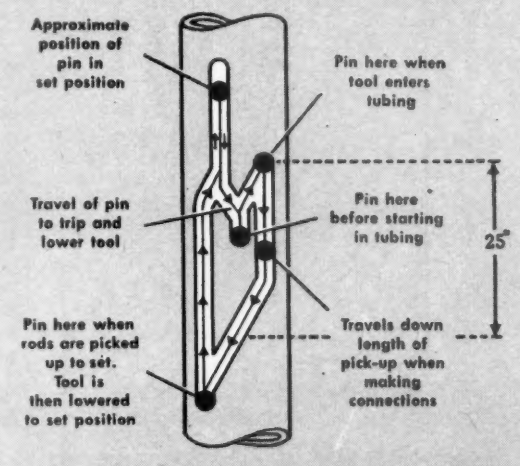
oilmaster INSERT PUMP ANCHOR

a tool designed to anchor an insert pump at any point in the tubing


Approximate position of pin in set position
Pin here when tool enters tubing
Travel of pin to trip and lower tool
Pin here before starting in tubing
25"
Pin here when rods are picked up to set. Tool is then lowered to set position
Travels down length of pick-up when making connections

CAN BE SET WITH VERTICAL MOVEMENT ONLY

CAN BE RESET WITHOUT ROUND TRIPPING

CAN BE SET WITHOUT ROTATION

Manufactured under license from Knowlton Oil Tool Co.

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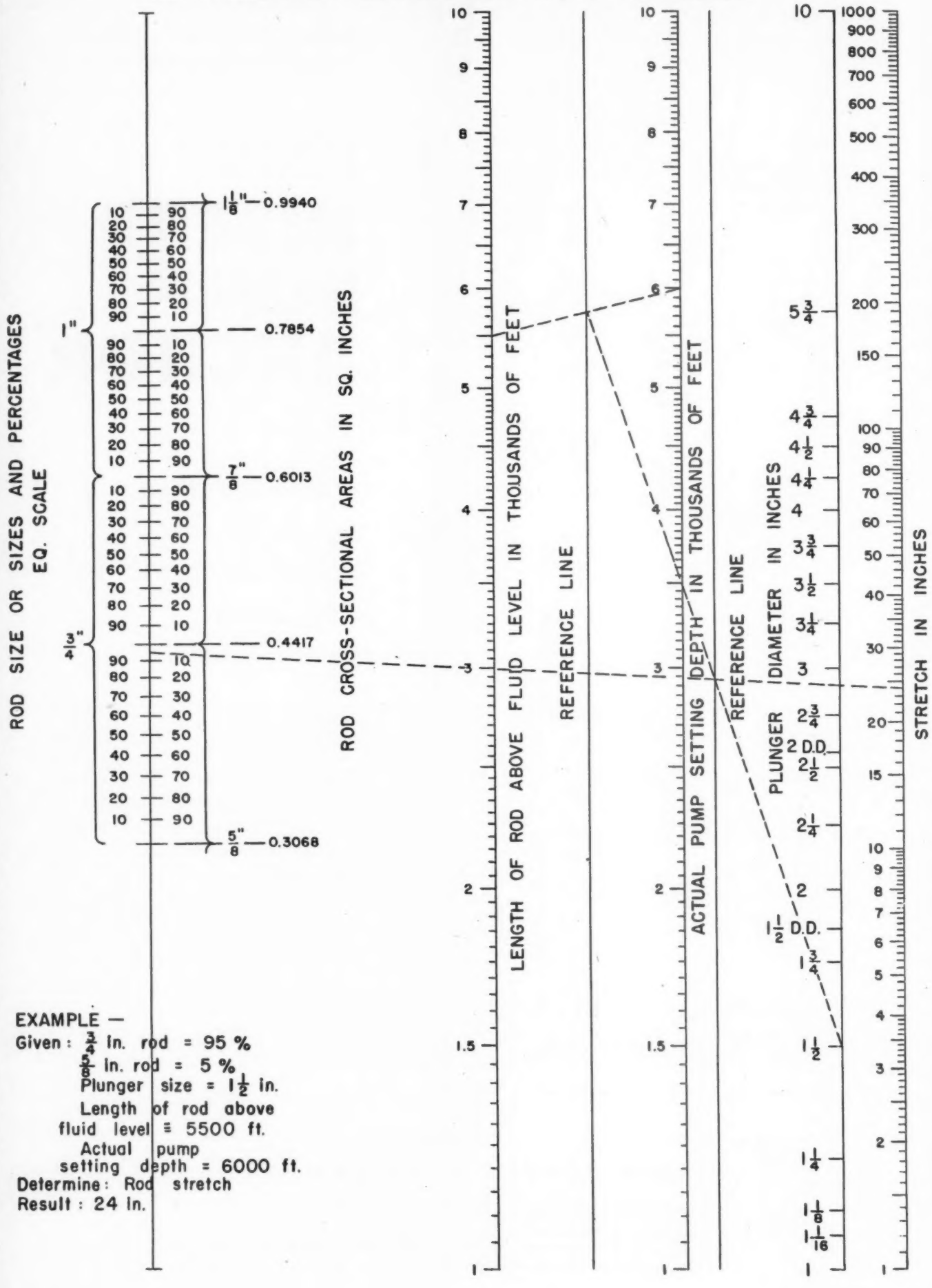
FIG. 17. SUCKER ROD STRETCH — SINGLE AND TWO WAY STRINGS.



EXAMPLE —
Given: $\frac{3}{4}$ in. rod = 95 %
$\frac{5}{8}$ in. rod = 5 %
Plunger size = $1\frac{1}{2}$ in.
Length of rod above fluid level = 5500 ft.
Actual pump setting depth = 6000 ft.
Determine: Rod stretch
Result: 24 in.

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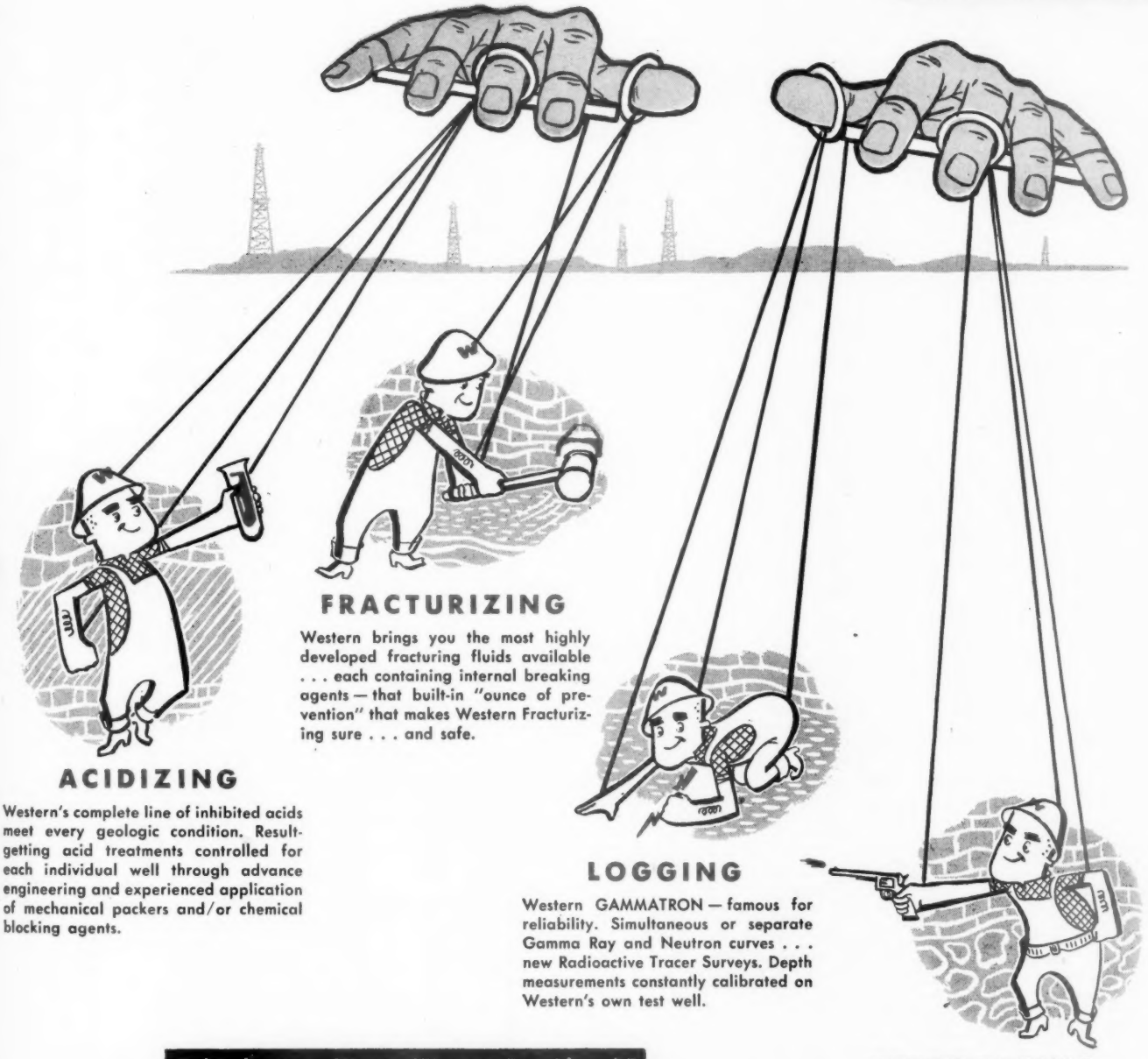

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FIG. 18. THREE AND FOUR WAY ROD COMBINATION CONVERSION SCALE.

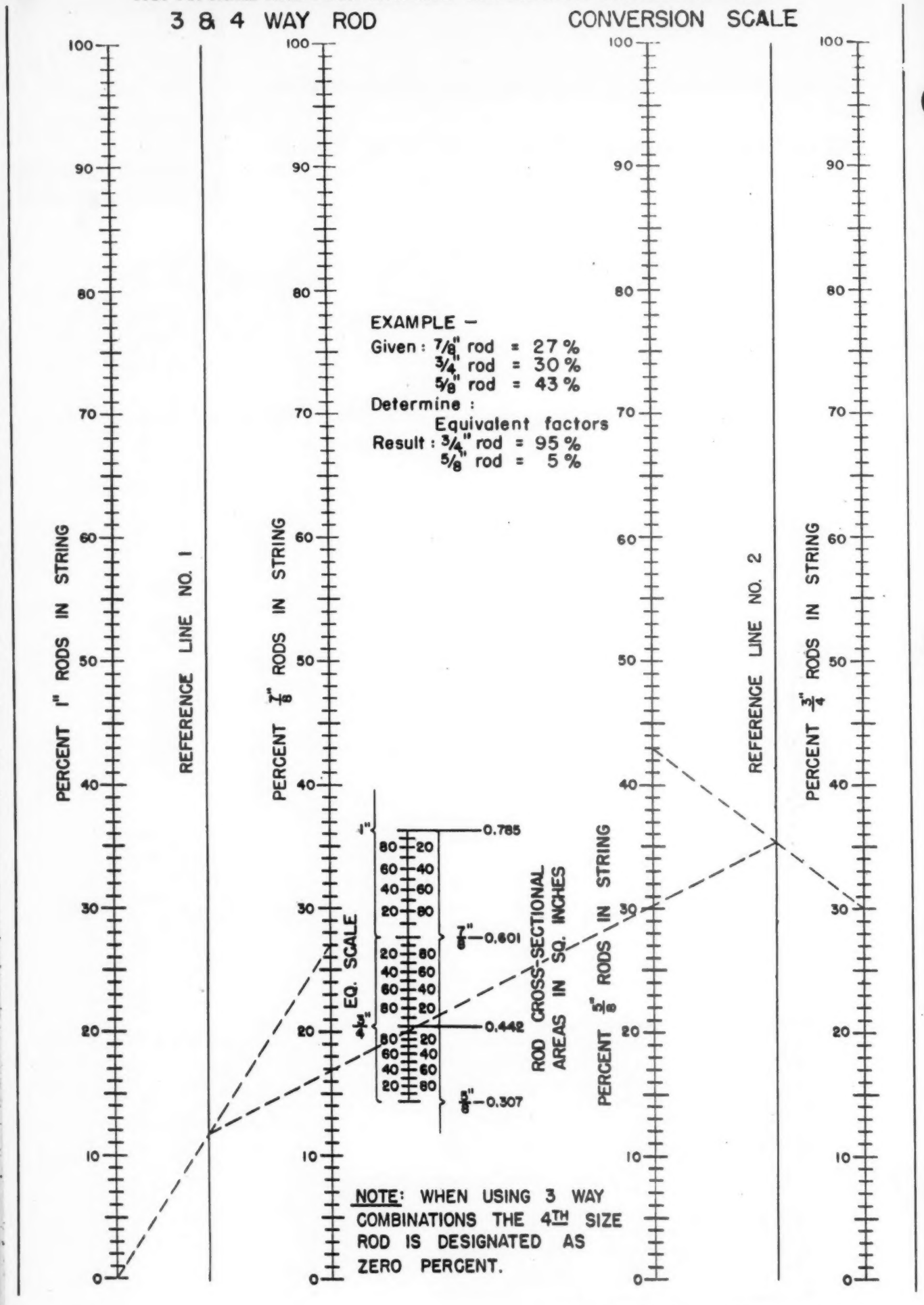
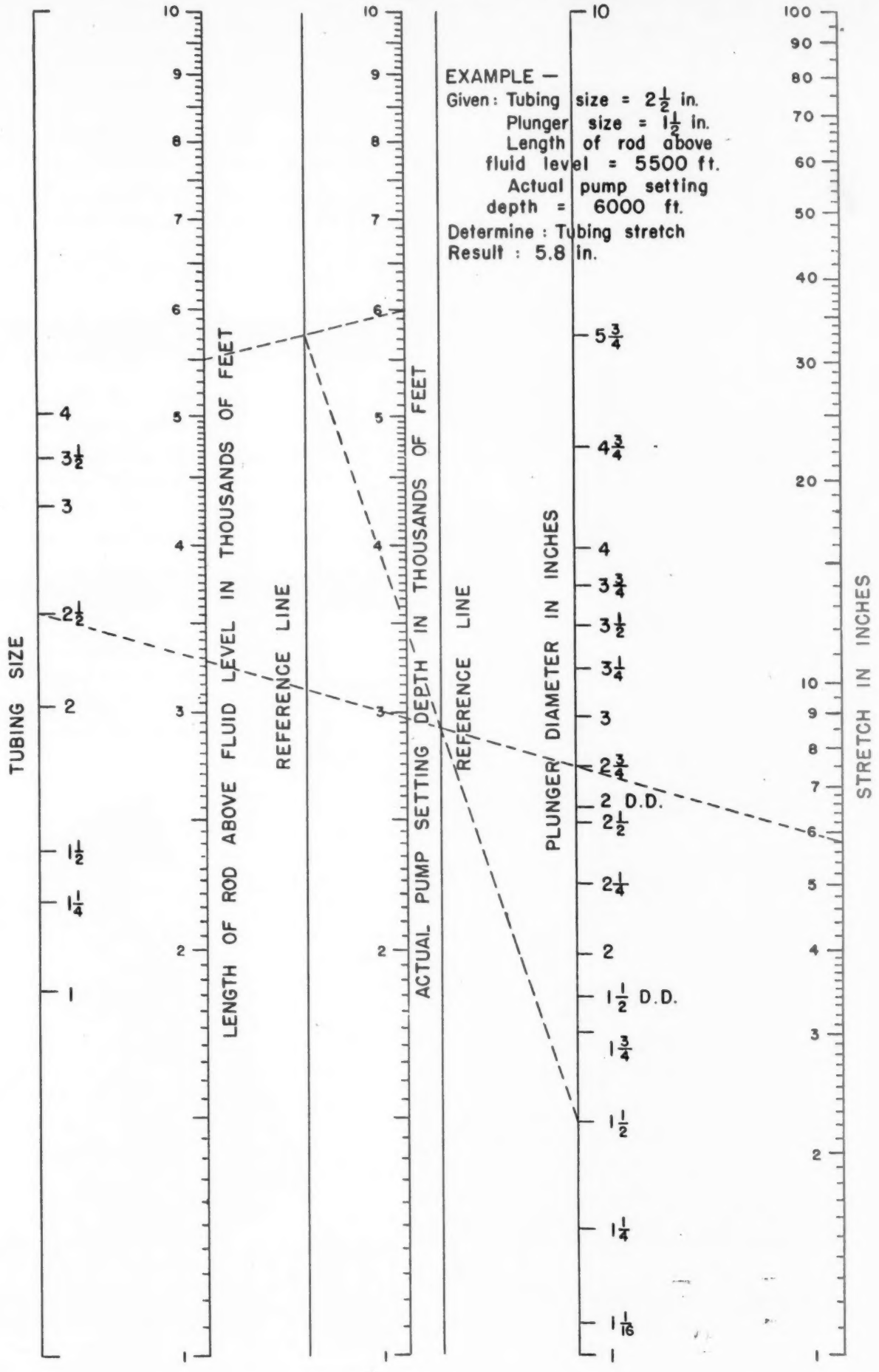


FIG. 19. TUBING STRETCH.


EXAMPLE —
Given: Tubing size = 2½ in.
Plunger size = 1½ in.
Length of rod above fluid level = 5500 ft.
Actual pump setting depth = 6000 ft.
Determine: Tubing stretch
Result: 5.8 in.
TUBING SIZE
LENGTH OF ROD ABOVE FLUID LEVEL IN THOUSANDS OF FEET
REFERENCE LINE
ACTUAL PUMP SETTING DEPTH IN THOUSANDS OF FEET
REFERENCE LINE
PLUNGER DIAMETER IN INCHES
2 D.D.
1½ D.D.
STRETCH IN INCHES

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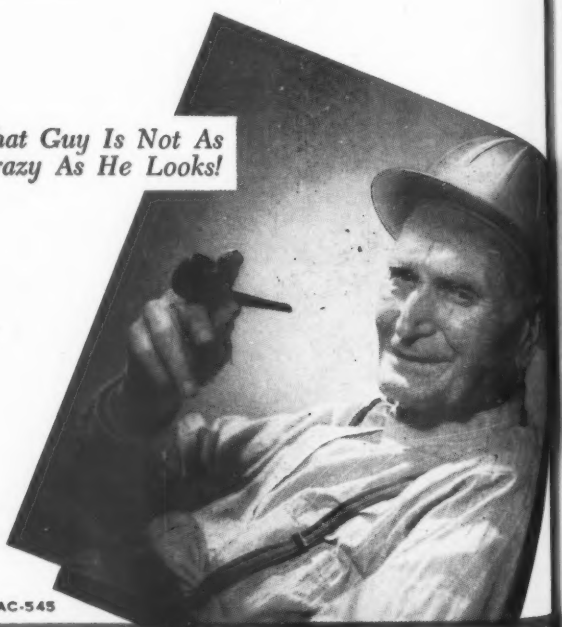

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that can be installed in a given tubing size. The following chart lists the maximum pump size and type pump that can be installed in the various tubing sizes. Use of an on and off tool permits the installation of larger pumps in a given tubing size than the chart indicates but such installations are made only in special instances.

Pump Plunger Constants. The constant for any pump is merely a factor which when multiplied by the stroke length in inches times the strokes per minute will give the pump displacement in barrels per day. The pump constant for any given pump is equal to $\frac{1440}{9702} A_p$ where 1440 is equal the number of minutes in 24 hours, 9702 is the cubic inches in a standard 42-gal barrel and Ap is the area of the pump plunger.

Fluid Level

For the purpose of the selection curves, the operating fluid level was assumed to be at the pump since maximum loads occur at pump off conditions. Certainly some pump submergence is necessary for satisfactory pump operation and efficiency. In general some 500 ft is desired. In those cases where the well productivity is sufficiently defined that the operating fluid level is known then the pump submergence should be considered in the calculations. Use of the selection curves in this case will give conservative production figures and slightly higher than actual polish rod loads, but would indicate the proper range of equipment selection. Individual well calculations would then dictate the specific installation components to be selected.

Fluid Specific Gravity

The produced fluid was assumed to have a specific gravity of 1.0 in all of the calculations made in the compilation of the selection curves. The specific gravity of 1.0 normally gives satisfactory accuracy for wells in water drive reservoirs. For high gravity crudes where little or no water is produced, it is normally desirable to use the actual specific gravity of the well fluids. The specific gravity of the various API gravity crudes and for water-oil mixtures may be determined from Fig. 12.

Sucker Rods

Tapered rod strings are used to reduce the weight and to distribute the loading to better advantage on long strings of rods. The per cent of each size rod in tapered rod strings, shown in Fig. 13 have been determined for the various size pumps. Percentages have been calculated to provide equal stress in top of each rod section.

For purpose of this manual and in the selection curves, application of sucker rods has been limited both by load and tubing size. The type rod has not been specified except on the selection curve for the API 640 unit where it was evident that high tensile rod would be required to permit loading of this unit. In most instances, the type of sucker rod is a special problem for each area and is dictated by the load requirement, the corrosive nature of the well fluids, etc. In general we have found that with average operating conditions, sucker rods can be safely loaded to about 27,000 psi (high tensile rods can be loaded to some 36,000 psi or more). In our selection curves we have attempted to maintain the rod stress as low as practical.

In addition to the limits placed on rod loads, application of sucker rods has been limited as to the minimum size rod to be used in a given size tubing. Experience has shown that if small rods are used in large tubing with medium to fast pumping speeds, the small size rods have insufficient rigidity and excessive fatigue failure results. Minimum recommended rod size to be used in given size tubing are shown below:

	Inches		
Tubing size	2	2½	3
Minimum rod size	⅝	¾	⅞

In conformance with this limitation, tapered tubing strings may be used if desired.

Acceleration Factors

Several authors have proposed formulas for the determination of an acceleration factor to be used in theoretical sucker rod calculations. The formula proposed by Mills has been adopted for use in this manual as it appears to give results more in keeping with measured loads.

Counterbalance Requirement

Maximum counterbalance requirement is considered to be equal to the static weight of the rod plus one-half the weight of the fluid.

In the selection of beam pumping units, it is important that the unit be selected with sufficient counterweight to permit counterbalancing of the maximum load conditions to be encountered. It makes no difference whether this counterbalance requirement is met by the use of standard counterweights alone or whether auxiliary weights are used so long as the unit is not operated at overload conditions. Where maximum ultimate loads are not well defined, however, it is desirable to provide the calculated counterbalance requirement with standard weights alone. Then, if higher than expected loads are encountered, the use of auxiliary weight may be used. In the past in a number of installations the operating capacity of an installation has been limited because of insufficient available counterbalance.

Peak Torque

Peak torque is the basic factor that determines size of the pumping unit required. Of the several limiting factors, no other factor so initially controls the capacity of a beam unit to do work. Actually the torque imposed on the gear reducer of a pumping unit is the algebraic sum of the well load torque and the counterbalance torque. Therefore it is important in operation that careful attention be directed toward keeping the unit in proper counterbalance at all times.

In theory and under ideal conditions it should be possible to counterbalance the static weight of the rods plus one-half the weight of the fluid. Therefore, peak torque could be determined by multiplying the accelerated upstroke load less the counterbalance load (wt rod ½ wt fluid) times one-half the polish rod stroke length. In our experience, however, it has been determined by dynamometer tests that for the most part or actual peak torque requirements were somewhat higher than would be indicated by the above calculation method. We have, therefore, established by means of correlating dynamometer data a set of peak torque factors which are related upon plunger diameter. These peak torque factors are shown on Fig. 16.

Brake Horsepower

In order to obtain better accuracy and consistency of selection, we have reviewed the various methods used by industry and have devised a new method for calculating brake horsepower which should give much more consistent results.

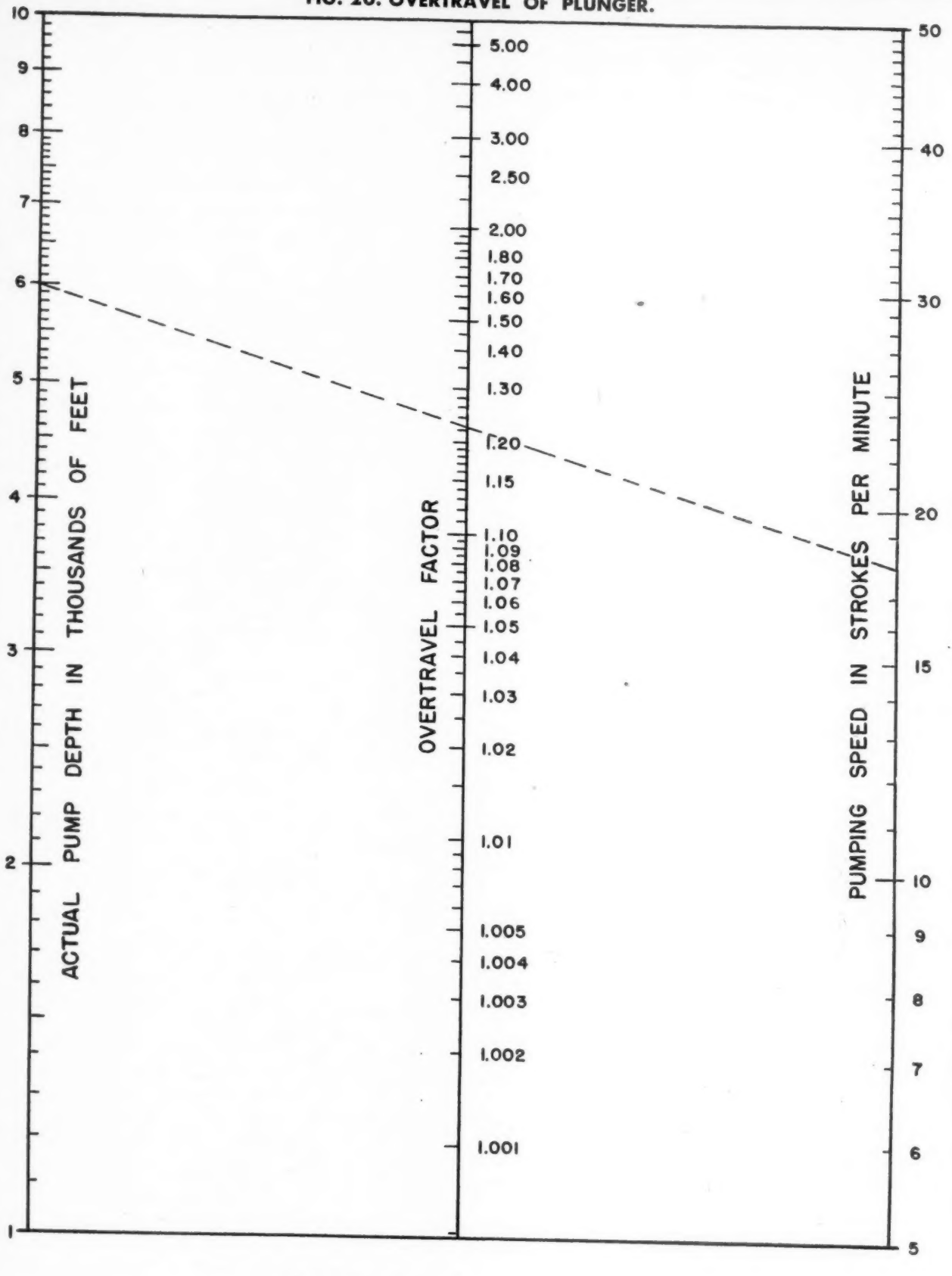
Our method for calculating brake horsepower is as follows:

Brake horsepower = (hydraulic horsepower + friction horsepower) (1.5) in which

$$\text{Hydraulic horsepower} = \frac{(\text{Fl. lift-ft})\ (\text{net plunger stroke prod.} - \text{bpd})\ (\text{sp. gravity})}{136{,}000}$$

$$\text{Friction horsepower} = \frac{(\text{pumping speed} - \text{spm})\ (\text{pol rod stroke length} - \text{in.})\ (\text{rod wt} - \text{lb})}{1{,}600{,}000}$$

FIG. 20. OVERTRAVEL OF PLUNGER.



EXAMPLE —

Given : Pumping speed = 18 SPM
Pump depth = 6000 ft.

Determine : Overtravel factor

Result : 1.225

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Cost of Drills (3)	6,000.00
Other Costs, including bits	7,850.00
Month Total	$23,650.00
Number of Profiles — 160	
Cost per Profile	$147.81

While using HAWTHORNE BITS . . .

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West Texas Division
INVOICE: May, 1954

Recording Costs	$ 9,800.00
Cost of Drills (3)	6,000.00
Other Costs, including bits	6,233.50
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Number of Profiles — 200	
Costs per Profile	$110.16

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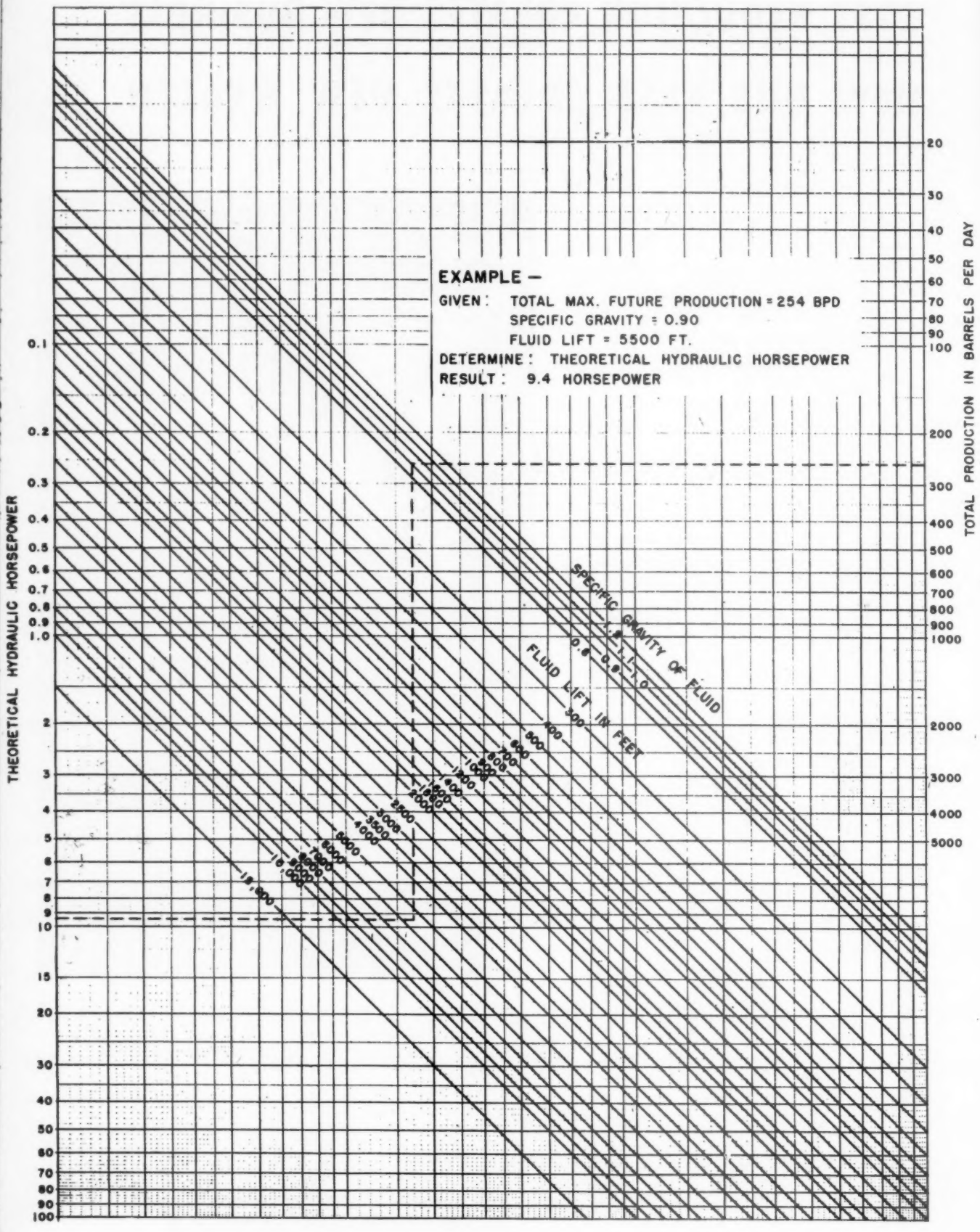
FIG. 21. HYDRAULIC HORSEPOWER.


EXAMPLE —
GIVEN: TOTAL MAX. FUTURE PRODUCTION = 254 BPD
SPECIFIC GRAVITY = 0.90
FLUID LIFT = 5500 FT.
DETERMINE: THEORETICAL HYDRAULIC HORSEPOWER
RESULT: 9.4 HORSEPOWER
THEORETICAL HYDRAULIC HORSEPOWER
TOTAL PRODUCTION IN BARRELS PER DAY
SPECIFIC GRAVITY OF FLUID
FLUID LIFT IN FEET

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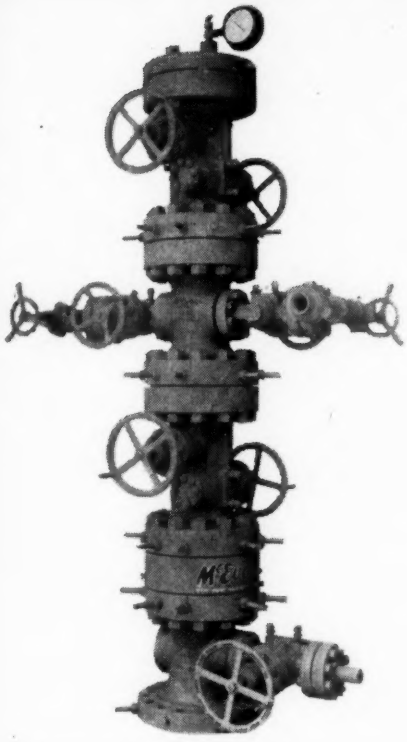

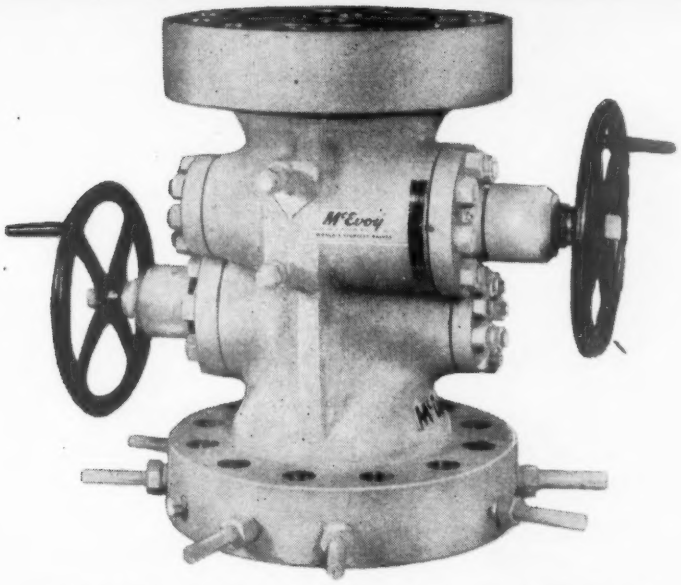

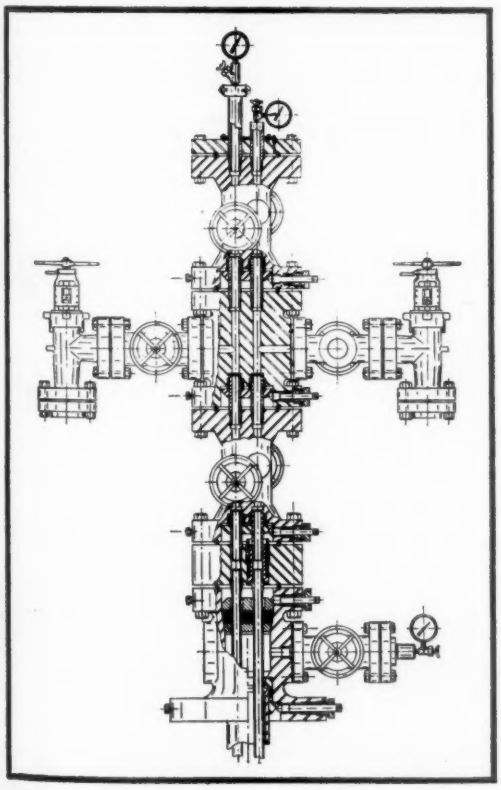

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- Complete vertical access to both tubing strings for all wire line operations.
- Permits cutting paraffin, running pressure and temperature bombs, storm chokes, etc.
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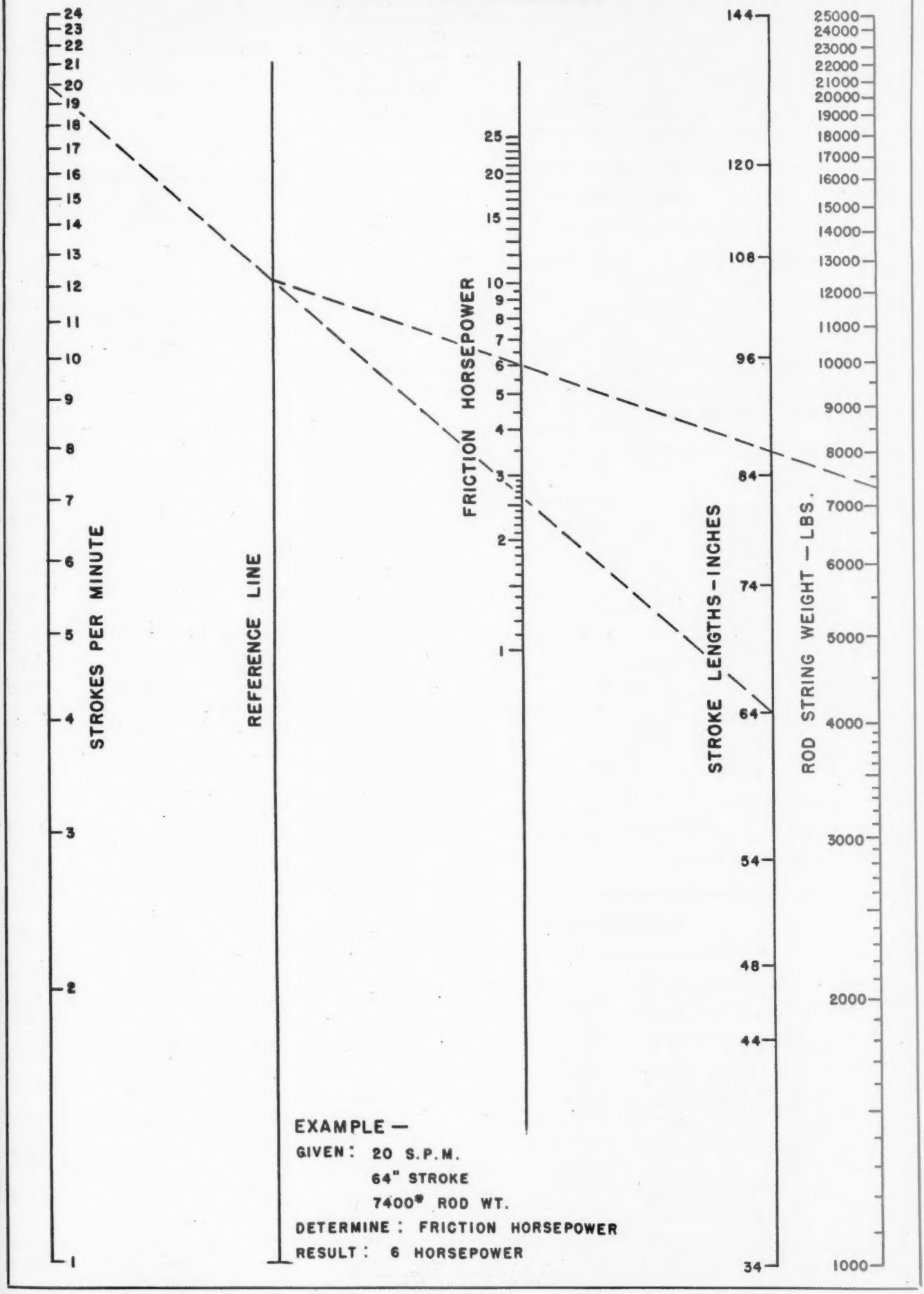
FIG. 22. FRICTION HORSEPOWER.



The factor of 1.5 provides for surface efficiency of the unit, counterbalance and prime mover drive.

Engines capable of delivering this calculated brake horsepower should then be selected from the 65 per cent API hp curve for multi cylinder engines and the 75 per cent maximum hp curves for single cylinder engines.

For the selection of electric motor the calculated brake horsepower should then be divided by a factor of 0.75 to obtain nameplate horsepower rating. The motor nameplate ratings are reduced to account for horsepower capacity which is lost because of motor heating resulting from cyclic loading imposed by rod pumping.

FIG. 23. ELECTRIC MOTOR SELECTION FOR CYCLIC LOAD APPLICATION

Nameplate horsepower	Usable brake horsepower for rod pumping application
5	3.7
7.5	5.6
10	7.5
15	11.2
20	15.0
25	19.7
30	22.5
40	30.0
50	37.5

Reduced brake horsepower = Nameplate horsepower X 0.75

Note: Nameplate horsepower has been reduced 25 per cent to account for the horsepower capacity which is lost because of motor heating resulting from cyclic loading imposed by rod pumping.

BASIC FORMULAE

1. Mills acceleration factor

$$\alpha = 1 + \frac{LN^2}{70{,}500}$$

α = Mills accelerating factor
L = Polished rod stroke length in inches
N = Pumping speed in spm

2. Specific gravity of oil and water mixtures

$$SG = \%H_2O(SG\ H_2O) + \%\ Oil\ (SG\ Oil)$$

SG = Specific gravity

3. Rod and tubing stretch

$$e = \frac{144\,W_f A_p L_1 L_2}{EA_r}$$

e = Elongation in inches
W_f = Wt fluid in lb/cu in.
A_p = Area of plunger in sq in.
A_r = Area of rod in sq in.
E = Modulus of elasticity in psi
L_1 = Fluid depth in ft
L_2 = Length of rod string in ft

4. Overtravel of plunger

$$OF = 1 + \frac{0.0193\,(LN)^2}{1{,}000}$$

OF = Overtravel factor
L = Length of rod string in thousands of ft
N = Pumping speed in spm

5. Hydraulic horsepower

$$HHP = \frac{(P)\,(W_f)\,(FL)}{33{,}000 \times 24 \times 60}$$

HHP = Hydraulic horsepower
P = Calculated net plunger stroke production in bpd
W_f = Wt per barrel of fluid in lb
FL = Fluid lift in ft

6. Friction horsepower

$$FHP = \frac{(SPM)\,(L)\,(W_r)}{1{,}600{,}000}$$

FHP = Friction horsepower
SPM = Pumping speed
L = Polished rod stroke length in inches
W_r = Rod string weight in lb

7. Brake horsepower

$$BHP = (HHP + FHP)\,1.5$$

BHP = Brake horsepower
HHP = Hydraulic horsepower
FHP = Friction horsepower
1.5 = Surface efficiency factor

8. Sheave size

$$S_u = \frac{S_e \times RPM}{SPM \times RG}$$

S_u = Unit sheave size in in.
S_e = Engine sheave size in in.
RPM = Engine speed
SPM = Pumping speed
RG = Gear ratio

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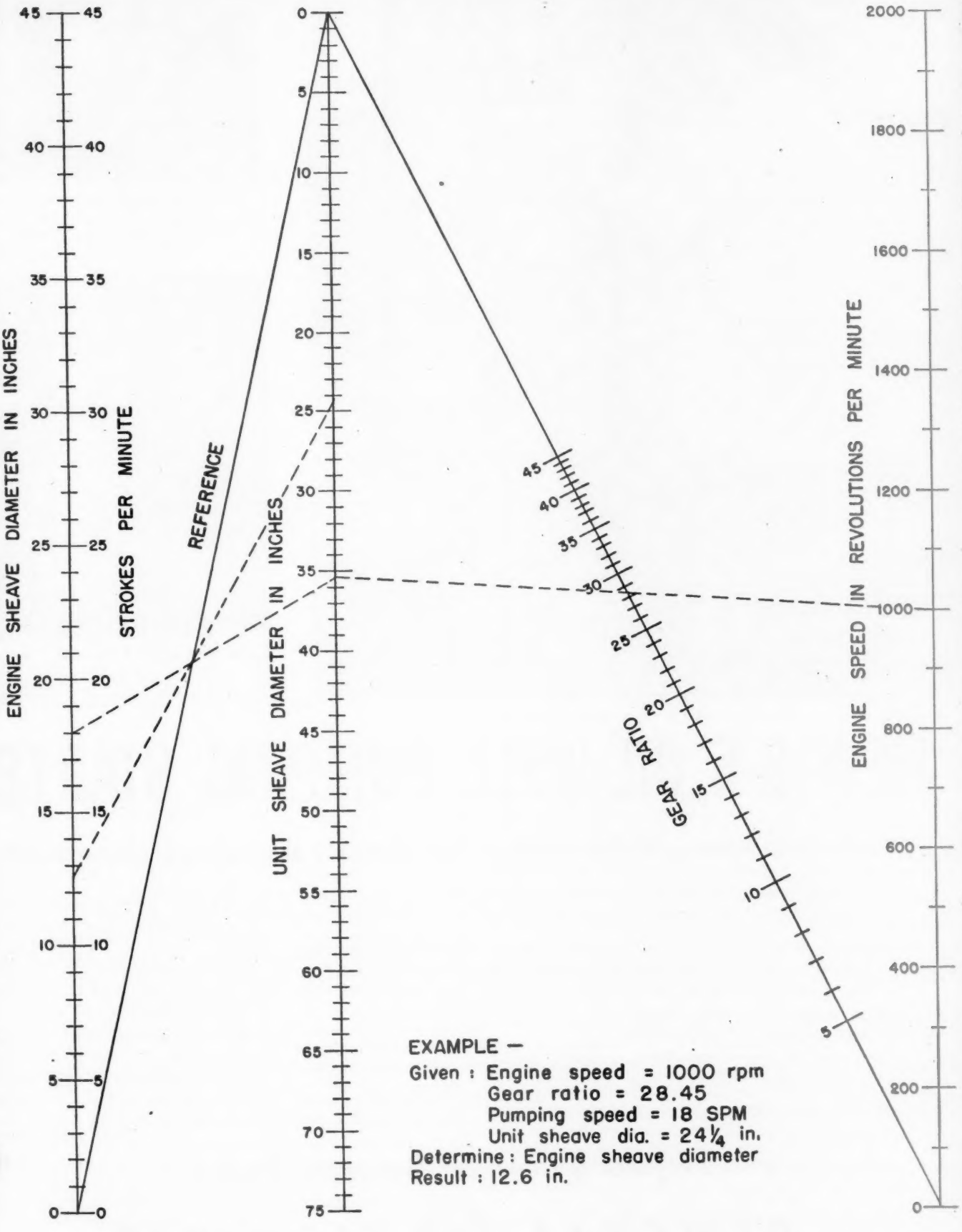
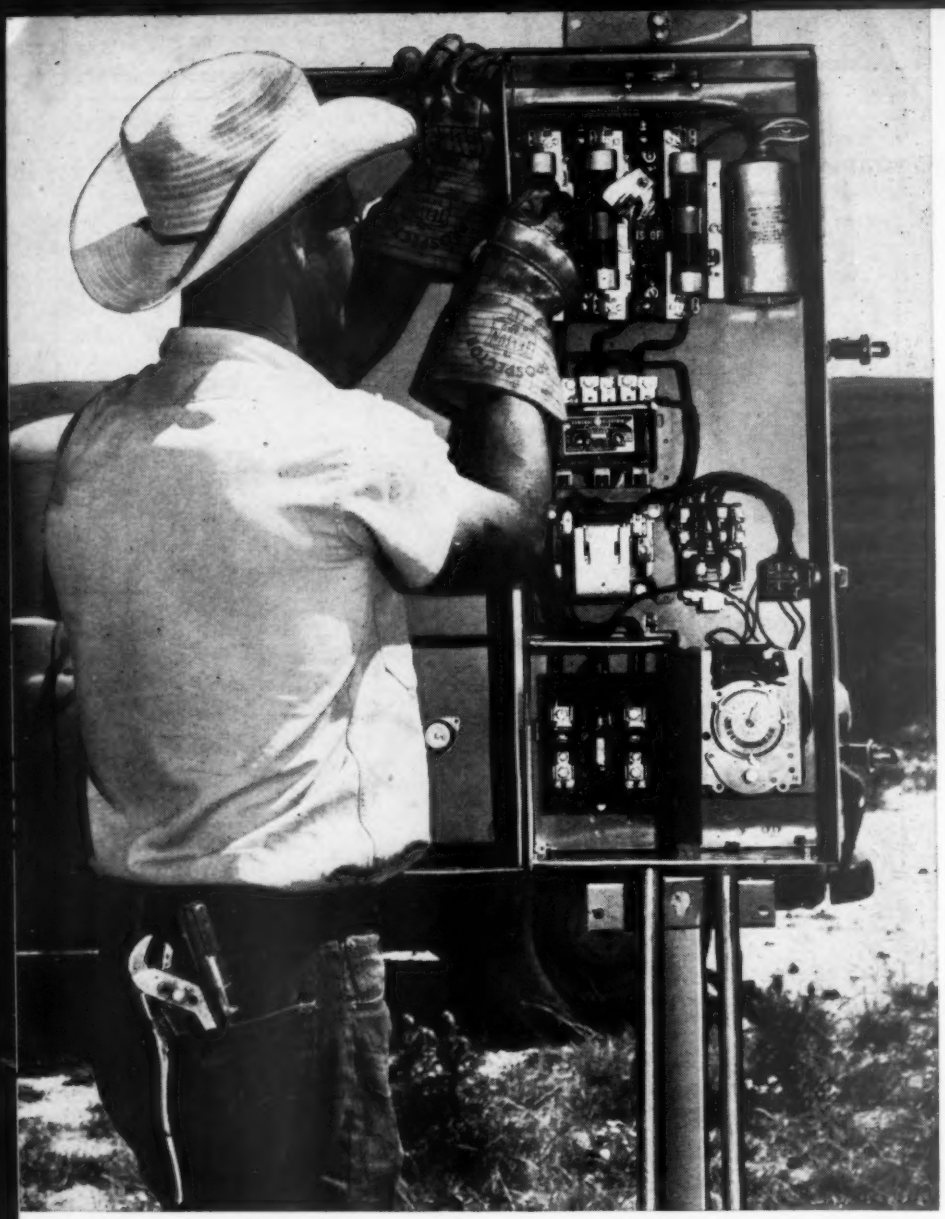
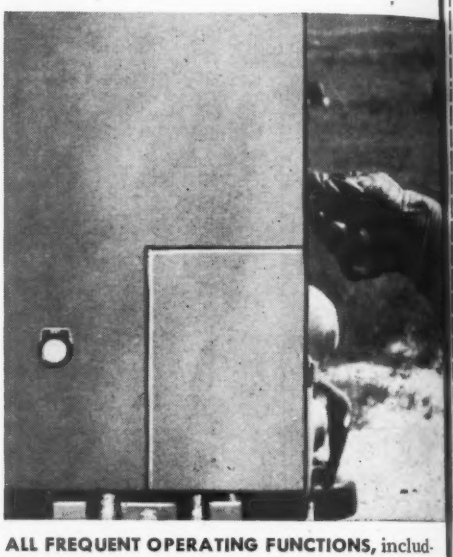
This is the third and concluding part of a series in three parts on Manual for Selection of Beam Pumping Equipment.

FIG. 24. NOMOGRAPH FOR DETERMINATION OF SHEAVE SIZES.


ENGINE SHEAVE DIAMETER IN INCHES
STROKES PER MINUTE
REFERENCE
UNIT SHEAVE DIAMETER IN INCHES
GEAR RATIO
ENGINE SPEED IN REVOLUTIONS PER MINUTE
EXAMPLE —
Given : Engine speed = 1000 rpm
Gear ratio = 28.45
Pumping speed = 18 SPM
Unit sheave dia. = 24¼ in.
Determine : Engine sheave diameter
Result : 12.6 in.



PROGRAM TIMER DOOR permits quick and easy access for adjusting timer. Padlocking of timer door will lock complete starter.



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MUD PROGRAMS AND MUD CONTROL

H. M. BARRETT*

KEY to successful rotary drilling is not so much mechanical rotation of the drill pipe as it is the washing clean of the hole by fluid pumped down this drill pipe. This makes possible a continuous operation for removal of drilled cuttings.

First such drilling probably took place about 1882 in the Dakota territory and was done by two water drilling contractors.[1] They poured water down the annulus and washed cuttings back up through the drill pipe. In 1895 the rotary method of drilling was used in the Corsicana oil field in central Texas. Most notable early well drilled by this method was probably the one drilled by Captain Lucas at Spindletop near Beaumont, Texas, in 1901.

In these early wells the water was pumped down the drill pipe, through the bit, and returned laden with cuttings to the surface through the annular space between the drill pipe and the walls of the hole. The early drillers observed that some of the clays which became accidentally mixed with the drilling water increased the ability of the water to keep the hole free of cuttings. The drilling mud industry grew from this small beginning until it now seeks special mud-making materials in all parts of the world.

Mud Circulating System

In a well being drilled by the rotary method, drilling fluid is circulated at all times as drilling is in progress. The mud-circulating system varies some, from one area to another, but in general it follows a standard plan. For convenience it is divided into two general parts. One part consists of the mud system above ground, and the other is that part of the system underground.

Above ground or surface system, begins with mud issuing from the top of the well and flowing through a flow line to the shale shaker and hence by gravity to the mud pits. It is taken from the mud pits through the mud pump suction, forced out through the discharge end of the pump through mud lines to the stand pipe. The rotary hose connects the stand pipe with the swivel. The mud passes through it and the kelly joint to go down the drill pipe underground. After passing through the bit, it returns to the surface outside the drill pipe, removing bit cuttings from the hole, and enters the shale shaker.

Surface System. The shale shaker or shale separator is a mechanical device for screening coarse cuttings out of the mud and removing them from the active mud system. It is one of two general types, vibrating or rotating. Screens for each type can be obtained in a choice of several mesh sizes. After leaving the shale shaker the mud returns to the pits or tanks. These mud tanks or mud pits vary greatly in size and method of construction. They are either constructed of steel or dug in the ground. Tanks are usually about 25 ft long, 8 ft wide, and 6 ft deep. The number used is between one and four. They are connected by large diameter pipes, usually a size between 7 in. and 10¾ in. Guns are fitted, either surface or submerged, so that mud in the tanks can be stirred. Tanks are often arranged so that one or more can be taken out of the system. Where earthen tanks, or pits, are used they are usually dug by a bulldozer and are divided by earthen or wooden dividers.

In many cases the surface mud pits are designed for ease of transportation rather than for efficient mud maintenance. Their volume must be such that (1) any entrained gas can be released before the mud enters the pump suction, (2) as many cuttings as possible, which are fine enough to pass through the shale shaker screen, will settle out of the mud stream and be collected on the mud pit bottom, (3) small mud losses to the formation will not deplete mud in the pits, (4) spots of mud not up to specifications will mix with enough good mud to cause no hole trouble, and (5) enough mud is available for keeping the hole full when the drill pipe is pulled. For wells deeper than 8000 ft, the mud pit volume is usually between 300 and 400 bbl.

Adjoining the mud tanks on the side away from the drilling rig is usually a large earthen pit used to hold discarded drilling mud in reserve. Any drilling mud which must be so discarded is jetted or pumped into this reserve pit. Use of reserve mud and ability to get it back into the circulating system often means a substantial savings.

The suction pump is usually a two-cylinder duplex power pump being driven from the same engines that drive the draw works and rotary, or from a separate engine used only for pump motivation. Sizes vary for this pump but in recent years there has been a decided trend toward larger volume pumps requiring greater amounts of power.[2] There are pumps on the market requiring 700 or 800 hp for capacity operation. Mud discharged by the pump passes through a mud line usually made of extra heavy pipe to the standpipe that is placed in one corner of the derrick. Attached to it is the rotary hose, the other end of which is connected to the swivel. This hose and standpipe arrangement makes it possible for the swivel to be raised and lowered while mud is still passing through it.

Underground system. At this point the mud enters the underground portion of the circulating system. It is pumped down the drill pipe, through the drill collars, out of the bit nozzles into the hole that is being drilled by the bit. It then is forced up the hole on the outside of the drill collars and drill pipe until it reaches the surface and moves through flow line to the shale shaker. Time required for each circulation of this continuous operation varies according to how big and deep the hole is, amount of mud in the surface circulating system and size and speed of the pump being used. Amount of power expended in moving mud through this system at various rates and in several states of flow is receiving detailed study.[3]

Drilling Fluid Properties

A drilling fluid consists of a base liquid, usually water, into which is dispersed solids which range in size from a true solution, through the colloidal range, to suspended particles visible to the naked eye. Solids which are colloidal in size are decisive ones in a drilling fluid. Dissolved solids, usually salts, affect mud properties chiefly by their effect on the colloids. The larger solids affect the mud properties by supplying materials from which colloids are made.

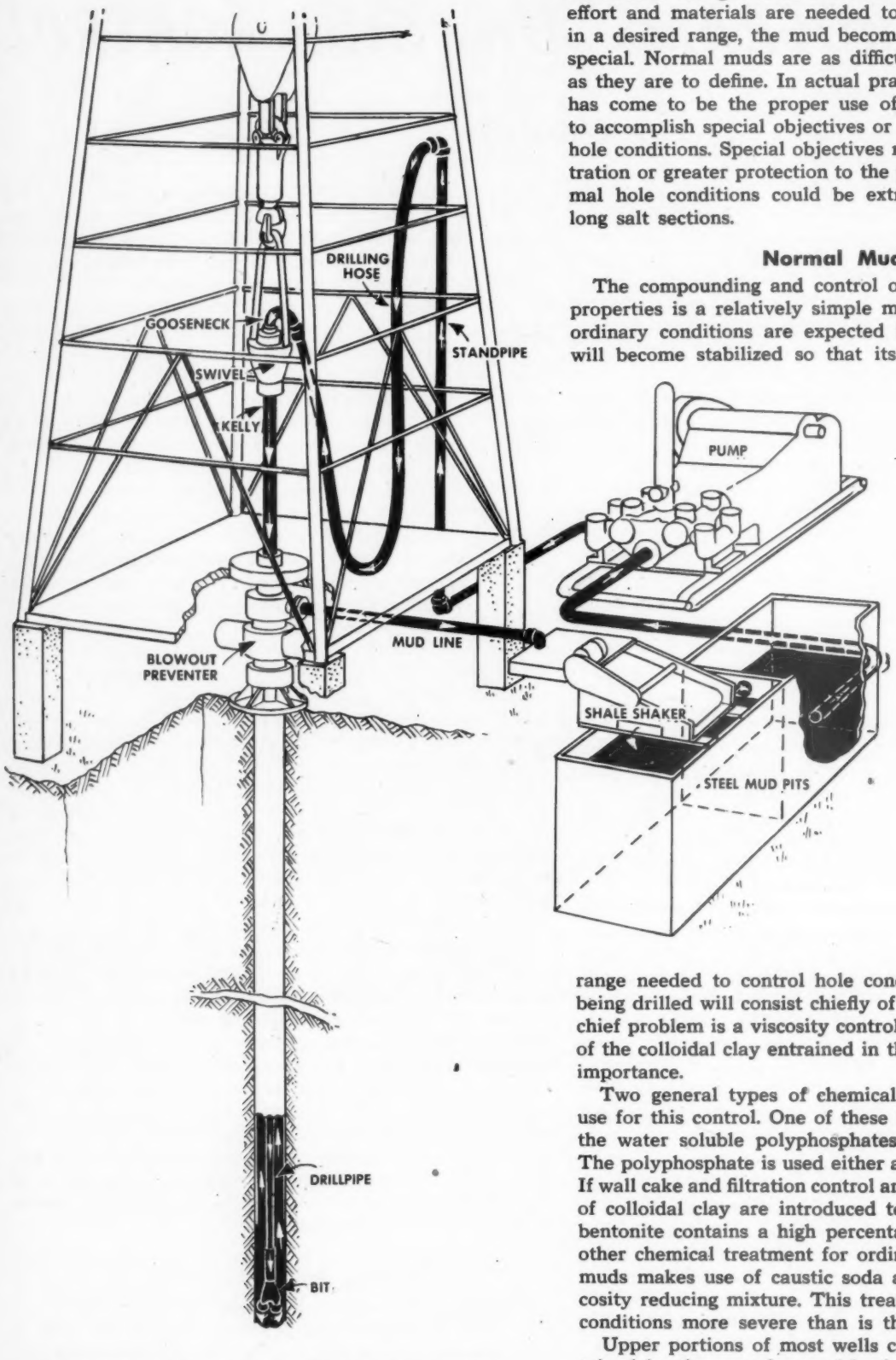
All drilling fluids have practically the same properties but it is the varying magnitude of these properties which is of great interest to the drilling mud engineer. Drilling fluids have weight,[4] viscosity, gel strength, wall building

*Phillips Petroleum Company, Oklahoma City, Oklahoma.

and filtration rates, and electrical resistivity. When little effort is needed to control the range of these properties the mud is thought of as a normal drilling fluid. As more effort and materials are needed to keep mud properties in a desired range, the mud becomes more abnormal and special. Normal muds are as difficult to find in the field as they are to define. In actual practice, mud engineering has come to be the proper use of special drilling fluids to accomplish special objectives or to overcome abnormal hole conditions. Special objectives may be faster bit penetration or greater protection to the producing zone. Abnormal hole conditions could be extreme gas pressures or long salt sections.

Normal Muds

The compounding and control of muds having normal properties is a relatively simple matter. Where no extraordinary conditions are expected in a well such a mud will become stabilized so that its properties are in the range needed to control hole conditions. The formations being drilled will consist chiefly of shale and sand and the chief problem is a viscosity control. Amount and condition of the colloidal clay entrained in the mud is of paramount importance.



Typical mud circulating system on rotary drilling rig. Mud is withdrawn from mud pits by pump; then forced through standpipe, hose, swivel, kelly, and drill pipe to bit. It then returns to the surface through the hole annulus and is cleaned of cuttings at the shale shaker and prepared for further service.

Two general types of chemical treatment are in wide use for this control. One of these treatments make use of the water soluble polyphosphates for reducing viscosity. The polyphosphate is used either alone or with quebracho. If wall cake and filtration control are needed, extra amounts of colloidal clay are introduced to the system. Wyoming bentonite contains a high percentage of such a clay. The other chemical treatment for ordinary water base drilling muds makes use of caustic soda and quebracho as a viscosity reducing mixture. This treatment is effective under conditions more severe than is the phosphate treatment.

Upper portions of most wells can be drilled and maintained by the use of a mud having normal properties. In many cases native muds produced by the formation solids dispersing in water are adequate. When normal chemical additions are begun, however, a treatment should be chosen that will not hinder the compounding of special muds to combat abnormal hole conditions, which may be encountered as the well is deepened. For example, if an anhydrite section is expected that will necessitate large additions of barium carbonate, the preliminary treatment should not

include phosphates, large quebracho treatments, or enough caustic to create a high pH. All of these suppress the reaction between barium carbonate and anhydrite.

Special Muds

There are a great number of so-called special muds. In general, they differ from ordinary muds in that they have been made resistant to a particular abnormal hole condition or a combination of such abnormal conditions. Here are some of these muds with their particular advantages and disadvantages.

Lime base muds. These are water base muds which have been treated with large amounts of caustic, quebracho, and lime. The order of addition is caustic, quebracho (or other organic thinner such as ground lignite or calcium ligno-sulphonate) and lime. Amounts vary but a typical treatment would make use of two pounds of caustic, one and a half pounds of organic thinner, and five pounds of lime added to each barrel of mud in the circulating system. Caustic is started into the mud stream along with enough chemical thinner to keep the viscosity of the mud in a workable range. After one circulation with probably half of the caustic and quebracho having been added, the lime is started in as a solid material through the hopper. The total amount of lime is added during one or two mud circulations and in three circulations all of the material will have been added.

The mud probably will have gone through a highly viscous stage but will reach a stable state of low viscosity. Gel strength will probably remain high for about 8 to 16 hours after which the mud will exhibit low thixotropic properties. Such a mud can tolerate large amounts of contaminating salts. Its particular ability, however, is to remain fluid when its solids content has been raised high. Lime base muds weighing 17.5 lb per gallon often have a funnel viscosity of around 45 seconds API. The great weakness that this mud system has is its tendency to solidify when subjected to high bottom hole temperatures. This high temperature gellation is affected very little by bottom hole pressures but is accelerated by increased amounts of either lime or shale solids.

Lime-treated muds. These muds are a compromise attempt at overcoming the high temperature gellation problem encountered when using lime base muds. They differ from lime base muds only in degree. Control is effected by the use of caustic and organic thinner and small amounts of lime. This system has overcome the worst aspects of heat solidification but the small treatments must be closely supervised and these muds are not nearly so resistant to contamination by salts encountered in the well as are the true lime base muds.

Emulsion muds. Oil in water emulsions are used as drilling fluids and exhibit several desirable qualities. Oil is being added to any of the regular or special water base drilling fluids with good results. No special mud properties are necessary and in many cases the emulsifying agents found naturally in a drilling fluid are effective enough to hold the oil in a tight suspension after it has been mechanically dispersed by the vigorous stirring it receives while circulating through the pump and down the hole. Special emulsifiers now in general use are the surfactants, the ground lignites, and sodium carboxy methyl cellulose.

Oil most generally used in emulsion type muds are crude oils and diesel fuel. Any available oil having a gravity between 25 and 50 API can be used. Crude oils containing large amounts of low boiling point components become uneconomical because of extensive evaporation losses. Emulsion muds vary in oil content between a low of possibly 1 per cent and a high of around 40 per cent. Muds containing 8 to 12 per cent of oil by volume have exhibited very stable properties easily maintained with low filtration and wall cake characteristics. Such muds allow a faster rate of penetration and reduce down-the-hole friction to a minimum.

A well dispersed emulsion mud creates no fire hazard itself but the mixing oil held in reserve constitutes some danger and oil spilled around the rig or allowed to remain on the mud in the mud pits is somewhat dangerous. Good emulsion muds are a little more expensive than similar water base muds without the oil. The chief objection to this drilling fluid comes from the geological department. The oil used, particularly if it is a crude oil, sometimes masks the staining, fluorescence and odor of the formation cuttings. Non-staining and non-fluorescing oils alleviate this condition. This objection is rarely raised except on wildcat wells.

Inhibited muds. The so-called inhibited muds or muds with inhibited filtrates have become fairly popular recently. Large amounts of dissolved salts are added to the mud. A high pH is usually thought necessary for best inhibiting results. A typical inhibited mud would be treated with caustic and quebracho in the usual manner except the amount of caustic would be increased to possibly two pounds per barrel of mud. To this is added a combination of sodium chloride and calcium sulphate. Quebracho, or another organic thinner, is used in initial stages of the treatment to maintain viscosity and gel strengths of the mud in a workable range.

The amount of salts used will vary but six pounds per barrel of sodium chloride and two pounds per barrel of calcium sulfate produces a filtrate containing 15 or 20 thousand parts per million sodium chloride and a hardness of about 200 parts per million calcium carbonate. Such muds are designed to reduce the amount of formation swelling caused by the filtrate.

Where producing sands contain large amounts of shale or clay, an ordinary filtrate swells the shale or clay, filling the space between the sand grains, and thus sealing the producing section immediately adjacent to the bore hole. Filtrates containing appreciable amounts of dissolved salts inhibit this swelling and hold it to a minimum. Cases of increased production have been reported where an inhibited mud was used and the need of formation fracturing has been eliminated in some instances.

These muds have certain inherent disadvantages. Detailed electric logs with ordinary equipment are not obtained in them. They require special attention and unless oil is used with them, low mud weights cannot be maintained. Increases in viscosity are hard to make because the clay added for this purpose does not swell in such a mud. Salt destroys the natural wall building properties of the clays present in the mud and so filtration control must be maintained by the use of non-clays such as starch or sodium carboxy methyl cellulose; normally, sodium carboxy methyl cellulose is more efficient for this purpose.

Gypsum base muds. A specialized type of inhibited mud has been used in the northern Rocky Mountain area, through the Dakotas and up into Canada. This mud contains large amounts of calcium sulfate in the form of either agricultural gypsum or plaster of paris. To a regular water base mud composed of clay and water is added two pounds per barrel of gypsum. Thinner is not usually added and a mud results having high initial and high 10 minute gels. Filtration properties are controlled by addition of organic colloids such as starch or sodium carboxy methyl cellulose. When starch is used it must be protected from fermentation by the addition of a preservative. Paraformaldehyde and Dowcide "G" are the two most commonly used preservatives.

These muds are fairly stable, economical to maintain and their filtrate does not swell to a great degree the bentonite streaks found in these regions. High gel strengths, particularly the initial gel, cause the muds to hold and recirculate any gas which might become entrained in them.

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For the same reason, fine abrasive sand often encountered in the Rocky Mountain area remains in the mud where it causes excessive pump wear.

Oil base muds. All of the muds described so far have had water as their liquid phase. Another liquid which can be used as the dispersant in a drilling fluid is oil. When oil is used the materials to be dispersed in it must be oil soluble and capable of imparting to the fluid proper characteristics for making a usable drilling fluid.

Most of the oil base muds being used at the present time are compounded in central storage tanks and taken to the oil well in a liquid condition. Some sacked material, however, can be obtained to add to a special oil to produce a good oil base mud. One such mud uses for its base a furnace oil having certain specifications. To a barrel of this oil is added blown asphalt and a small amount of unslaked lime. The blown asphalt gives viscosity and a certain amount of thixotrophy to the fluid. It also provides material for filtration control. The unslaked lime gives further viscosity control and guards against fresh water entering the system to form a water and oil emulsion. Other control chemicals are used in very special instances.

Oil base muds contain no water and so cannot swell clays or shales with which they come in contact. Much information is in the literature concerning the higher productivity of wells drilled with oil base muds when compared with those drilled with a water mud. The extremely good lubricating properties of oil base muds allow closer tolerances to be used in a well without great danger of pipe sticking. In many instances the intense heat from both bullet and jet type perforators solidifies the clays in a water base mud so that the perforations become plugged. This is not true where the perforating is done in an oil base medium. These muds are expensive and dirty to work with. Conventional electric well logging technique cannot be employed in them. Their viscosity varies greatly with their temperature.

Inverted emulsions. A mud having some of the advantages of a true oil base mud but being somewhat cheaper is a water in oil emulsion. This is the so-called inverted emulsion. Inverted emulsions can be compounded several ways. The usual method is employment of a special emulsifying agent which tends to hold the water dispersed into the oil. Oil is usually the biggest component and the water is added to it. This order of addition is important. The presence of certain salts also helps this type of emulsion.

No great amount of experience has been obtained with these emulsions but they have about the same advantages and disadvantages that true oil base muds have. They are somewhat less stable but they are also less expensive.

Salt water. Salt water, either partly or completely saturated, is used as a drilling fluid under several conditions. In workover operations it is used as a special type of inhibited mud causing very little damage to exposed producing formations. Its weight can be varied by the addition of extra amounts of salt up to the saturation point. Saturated salt water weighs about 10 lb per gallon. Salt water has no wall building properties, however, and is very readily lost to any slightly porous formation.

Silicate mud. Sodium silicate drilling fluids were the first to drill successfully the so-called heaving shales in the Gulf Coast area. They are composed of sodium silicate and saturated salt water. This mixture has what is described as a pickling effect upon shales which prevents them from heaving or falling into the hole. Actually, this is another example of an inhibited filtrate. The weight of these muds probably aided in keeping shales in place also. The natural weight of this mixture is just over 12 lb per gallon. It can be weighted higher by the addition of barite.

The silicate muds, however, have some disadvantages and their use is not really as extensive as it once was. The 12 lb per gallon which they weigh is their minimum weight. If a lighter mud is needed another type must be chosen. Silicate muds are corrosive and expensive. Poor electric logs are obtained where they are present.

Low solids. Excessive amounts of clay and shale solids have always been detrimental to a good drilling fluid.[6] These extra amounts of clays and shales are expensive to treat, make thick dangerous wall cakes and produce an unstable mud. It has been found that it is beneficial to keep the amounts of these materials in a mud even below what has previously been considered a normal amount.

Low solids muds have shown themselves to be advantageous in promoting faster and safer drilling. When oil is added to a water base mud which contains a very minimum of clay solids, a very good drilling fluid results. There are three ways that clay solids can be removed from a drilling fluid. (1) by water dilution, (2) by circulating through enlarged surface pits, and (3) by the use of a centrifuge.[7] When clay solids are thus removed mechanically a very minimum of viscosity control chemicals are needed. Reducing the viscosity and gels becomes a small problem and inexpensive.

When viscosity and gel strengths become too low due to the removal of claylike solids, they are replaced by an organic or suspending material such as sodium carboxy methyl cellulose. These materials also make a very tight oil in water emulsion when oil is added to the system. These lows solids emulsion muds are very stable, easily maintained, and lend themselves very readily to drilling programs which involve large pumps and high mud circulating volumes. Faster drilling has always resulted when this type mud system is used. On the Gulf Coast where high mud weights are necessary and a centrifuge is available, this method of controlling mud properties has been very economical. Where the clay solids in light weight muds are removed by dilution, settling, or centrifuging, the economics are not too certain.

Disadvantages of excessive dilution are apparent. Usually the excess must be jetted to the reserve pit and often water is difficult to obtain. Large circulating pits or circulation through the reserve pits have some disadvantages such as extra cost of tanks and excessive dilution in case of hard rains. A centrifuge on a drilling rig is another piece of equipment which must be moved, maintained, and serviced.

Conclusion

As wells get deeper and the total cost of drilling them becomes greater, proper selection and close control of the drilling fluid plays an increasingly important part in the success or failure of the operation. To obtain the greatest success most economically the mud program must be well planned and then well executed. To have a good plan and then not follow it is wasteful. To try hard with no program is just as a wasteful. Both are dangerous in many cases. The close supervision of drilling fluids by a trained mud specialist has now become a routine part of today's drilling program.

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POWER PLANTS

O. B. Freeman*

IN any study of drilling engines, the first and most important source of power is steam. This is true for two special reasons, the first being historical. In the early days of the oil industry, steam although not the only power known, was the only power used. Boiler plants were thick on a busy lease and a net work of steam lines covered the ground. To illustrate the number of these lines, a story was common in the semi-desert west side fields of California's San Joaquin Valley. It was to the effect that, "When the weather got so hot the ground squirrels and chipmunks climbed onto the steam lines to cool their feet, one knew that summer had arrived." Today in these same fields it would be hard to find an uninsulated steam line crossing a lease.

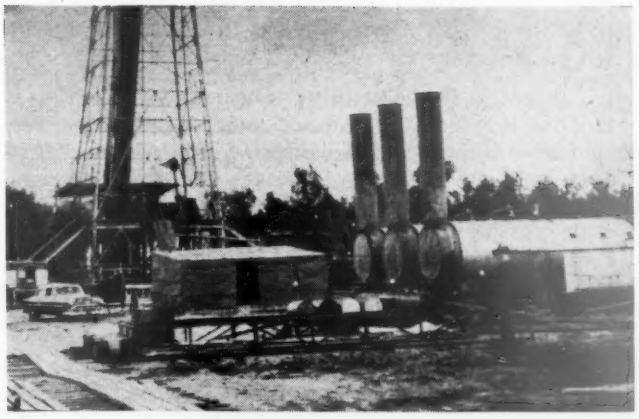
A second reason makes the subject of steam important. Steam is still the best and most flexible drilling power we have. It is the yardstick by which we measure the efficiency of all other prime movers. It is the simplest and most easily maintained of all. Any roughneck can repair a steam drilling engine, or pump. The steam rig and its accompanying boiler plant have both undergone radical changes. In early days, 3 pots, usually of less than 50 hp each furnished steam at 100 to 125 psig to a small engine and even smaller mud pumps.

Steam Power

The modern steam rig is a far cry from the early one. It has a large high speed engine operating at 300 to 500 psig steam pressure. A battery of 5 or more oil field boilers of around 150 hp each is required to supply this steam. The "more" will probably be emphasized where the hole is deep and jet drills are used.

Lack of space prevents anything like a comprehensive study of a steam power plant. The highlights only with a brief "why" of them may be touched upon. One of the more popular of today's drilling engines is a twin with 14-in. by 14-in. cylinders. Maximum crankshaft speeds are 400 rpm for intermittent service and 250 rpm for constant speed work. Rated capacity is 1690 bhp at 400 rpm and 400 psig steam in the intake manifold. To make fast time coming out of the hole, it is necessary that the engine be capable of fast acceleration and deceleration. To obtain this, the engine is frequently built without a fly wheel. This results in extreme vibration at high speed. Because of the above, not only the shaft and bearings, but the entire engine must be built very rugged.

*Tide Water Associated Oil Company.



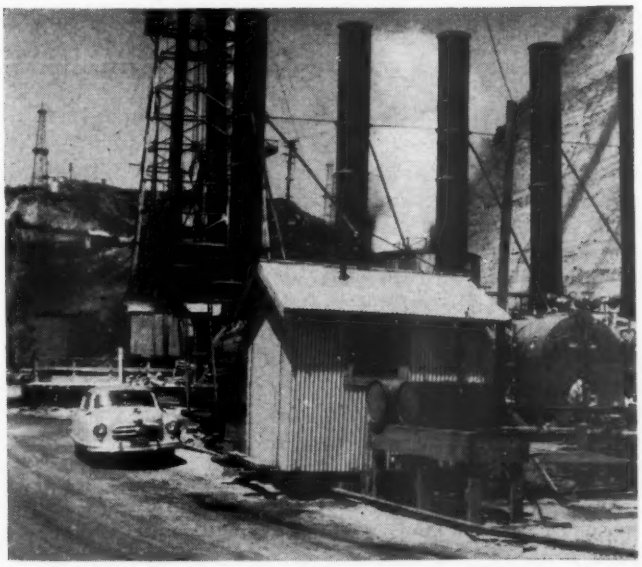
Gas-fired insulated boilers power steam rig at wildcat drilling site in South Texas.

The valve cut off is very late. Most low pressure industrial steam engines have been designed for a 5/8 valve cut off. When steam pressure was increased it was customary to shorten the cut off still more in order to take advantage of a higher steam expansion within the cylinder. This, of course, decreased the maximum power output but increased the overall thermal efficiency.

This drilling engine reverses the above idea of efficiency by being designed for a 7/8 cut off. High power output and high steam consumption is the result. It has the old time Stephenson type valve linkage familiar to all steam men. Piston type valves are used. Since the Stephenson linkage combines a reversing mechanism with the ability to shorten the cut off, some of the radical part of the design is cancelled out. Since to take advantage of this increase in steam efficiency would mean lowering of the engines power, it is safe to say that the driller will rarely take advantage of it. Speed and more speed is what he wants in his draw works.

At the present, steam powered drilling rigs are almost a thing of the past on the Pacific Coast. Among the causes would be the high price of fuel gas. The West, not being able to supply its own needs for fuel gas, must pipe in gas from the Texas fields. Fuel costs become quite an item in drilling with steam. Nature of the terrain also enters into the picture. Much of the western drilling is done in mountainous country. The Ventura Avenue and Chatsworth fields are good examples. In areas such as these where cost of excavating for a rig site may run as high as $50,000, excavating for boiler locations can and does run into real money.

Another factor is the number of contract wells now being drilled. At the present time the bulk of California oil well drilling is done by contractors. Since a contractor may be



One of last steam rigs in use in Ventura Avenue field, California. Rough terrain calls for costly excavating (right).

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in an established field today, and in the sticks on a wildcat tomorrow, he definitely leans toward a blitz rig and internal combustion engines.

Conditions described above are not universal. In the Mid-Continent and some other areas, gas is still plentiful and cheap. Much of the country is level which makes for cheap moving and rigging up. In such areas, steam drilling still is popular and will probably remain so for a considerable time to come. In fact, some of the western operators report a ready market in these areas for steam rigs they wish to retire. This being the case, the old time driller with his love of steam need not feel that he is a completely outdated person.

Gas-Gasoline Engine

In discussing industrial internal combustion engines, one should bear in mind that he is talking on a subject that is undergoing rapid and radical changes. More new changes in the concept of engine design have appeared in the recent past than at any time in history. Consequently, one should use care in making flat positive statements, else early future history may prove him wrong.

These advances are true of all types of engines, the Otto or 4 cycle, the 2 cycle and the Diesel cycle. Probably the first noticeable change was in cylinder pressures.

The gas- gasoline engines of a short time past were all low pressure naturally aspirated engines. Today they are being supercharged and cylinder pressures are approaching that of diesels. This supercharging first made its appearance on 2 cycle gas engines and soon became universal. It is now being taken up by designers of 4 cycle machines. These high pressure designs have already entered the drilling engine field. Some have now reached the point where further increase in pressure will produce pre-ignition and detonation. To overcome this and get higher cylinder pressures and horsepowers, engine manufacturers are now experimenting with chilling of combustion air between the super charger and the cylinder. This work was first started on the Diesel cycle. Excellent results are being reported.

Engine cooling is also undergoing radical changes. A very few years past, low cooling water volumes and temperatures were general. Temperature rises across the engine of 20 to 30 F were not uncommon. Today high water volumes and temperatures are a must. A temperature rise across the engine of more than 10 F is generally considered prohibitive. The value of cooling by boiling heat transfer is being more and more accepted. A really low temperature rise across the engine and a temperature above the dew point can be obtained in no other way. Also heating of the drillers' stand by steam, an important feature, can be obtained only by this very simple method of cooling.

Some manufacturers of drilling engines are now experimenting with aluminum pistons, vibration dampeners, and flame hardened crankshafts. This produces more power, speed, and flexibility. One manufacturer is now producing a 4 cycle natural gas drilling engine with a size and weight per bhp pound comparable with that of any diesel engine on the market. As a result of current changes, it is impossible to predict in detail the details of the drilling engine at even the early future.

Fuels. The Otto cycle or 4 cycle gas-gasoline engine is probably the most versatile drilling engine we have today. By ordering your engine fitted with a natural gas-gasoline carbureter you are able to use natural gas, our cheapest fuel. If this fuel is not available you can use either gasoline, butane, or propane. Natural gas, butane, and propane are all efficient under the same compression ratios. This means that the same cylinder heads would be used for all these fuels. If you wished, however, to use gasoline in your engine, it would be necessary to change to cylinder heads designed especially for gasoline to get maximum engine efficiency.

Temperatures. The combustion engine being a heat machine, temperatures are without doubt one of the most, if not the most important, feature governing its life, reliability and cost of operation.

The range of water temperatures leaving the engine is rather narrow. As you increase the temperature, the thermal efficiency of the engine increases up to about 200 F. Between 200 F and boiling, a loss of power can be expected. When you go above the boiling point, an entirely new concept of cooling is put into operation. You are then depending on boiling heat transfer to cool your engine. Power output increases again to a point greater than that obtainable with direct liquid phase cooling.

As it is impossible to keep a liquid cooled engine above the dew point, water is being constantly deposited on the cylinder walls and wiped down into the crankcase. If this water is allowed to remain, acids are formed that are seriously injurious to the engine. The only way to prevent this is to keep the crankcase temperature sufficiently high to drive the water out of the crankcase oil. On an engine operating indoors and protected from weather changes an oil temperature of 150 F is sufficient. A drilling engine, however, being out of doors and subject to weather changes, requires a minimum crankcase temperature of 165 F. The top temperature is not important so long as you stay within reason. A temperature of 225 to 250 F is permissable, 180 to 190 F is ideal. In checking the crankcase temperature be sure the thermometer is well down in the oil. If it is held above the oil level, a false, high reading will be obtained due to hot oil falling off the pistons and cylinder walls onto the thermometer bulb.

Lubrication. This is a subject that every man is an authority on whether he knows anything about engines or not. It will probably be safe, however, to make a few comments.

The fact that lubricating oils are constantly being changed and improved indicate that lubrication engineers are not satisfied with their own knowledge of the subject regardless of what the rank and file may think.

One change in our thinking regarding lubricating oils is the desirable viscosity. Twenty-five or 30 years ago an SAE 30 oil was spoken of as a "light" oil. Today an oil of the same viscosity is called a heavy oil.

Probably the most outstanding contribution to lube oils has been the advent of the additive or heavy duty oils. Although they are definitely an improvement, they also add certain problems, principal of which is the problem of knowing when to change oil in your engines. Many operators use a laboratory test. Some have their own laboratories. Others make use of commercial testing laboratories that are available at reasonable costs. No lab report is infallable but it is an indication.

A visual inspection will show some of the oil conditions only. Probably the most important item and the hardest to detect in time is the point of neutralization of the additives. Carbon entering the oil is dissolved forming a colloid. If the oil is left in the engine until the additives have been used up or neutralized the carbon starts to re-deposit on the walls and bottom of the crankcase. This deposit is a hard flinty granular material. Its effect is similar to throwing a hand full of sand into the crankcase. Any time such a deposit is found, the oil should be drained, the crankcase washed and new oil and filter put in, regardless of lab reports or length of time the oil has been used.

If oil changes are made on basis of visual inspection and length of time operated, play safe and change oil if in doubt. The old saying that oil is cheaper than machinery is still true.

Preventive Maintenance. This is an important although simple item. It is mainly a case of using common every day horse sense. Think of an engine as a living animal. As a race horse is limbered up before, then walked until cooled out after the race, so should the engine be warmed up and

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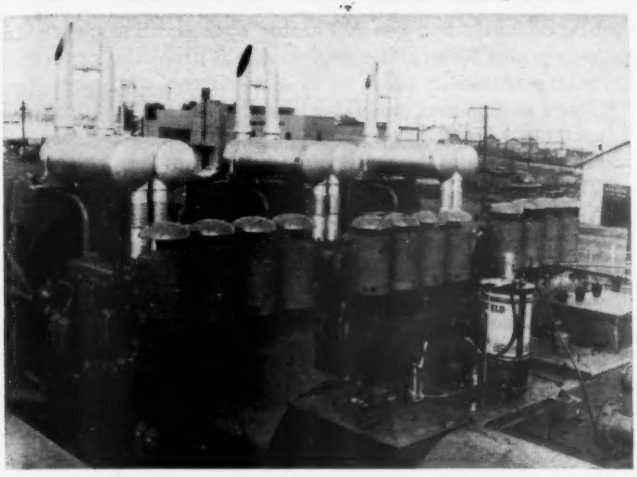

Modern, high speed, diesel engine equipped with torque converter.

cooled off slowly. There should be no prolonged periods of overload. Keep only clean oil in the crankcase and keep temperatures up. Watch fuel mixtures. Watch for and correct minor ailments before they become major ones.

Torque Converters. No other one thing has done as much as the torque converter to bring the combusion drilling engine into a class comparable with steam. Any combustion type engine with mechanical transmission is a rough operating machine on the draw works. In picking up a heavy load, it is necessary to speed up the engines before letting in the clutch. This means taking hold with a jerk and a jar. Excessive strains are thrown on the entire equipment. With a torque converter the output shaft drives your machines. This shaft speed is independent of the input shaft, that is, the engine crankshaft. Full engine power is applied throughout a long speed range of the output shaft. This type of drive, in the writer's opinion, is much more efficient when applied to drilling equipment than when used on automotive equipment. There is naturally an increase of fuel consumption and a loss of power in the driving oil. The first is not important to the driller. The second appears to be offset by the fact that the converter has the effect of giving the equivalent of a correct gear ratio at all times.

For this reason, it is excellently well fitted for use on drilling engines of either the spark plug or diesel types when all engines are manifolded together so that all or any part of the engines may work on draw works, rotary table or mud pumps.

Diesel Engines

There are two distinct types of diesel engines being used in oil well drilling today. The older is a large heavy duty engine with high weight per bhp. Typical are the Caterpillars, Superiors, and other makes of similar types. The second and newer are the smaller, high compression, high speed diesels such as that of General Motors. The principal argument in favor of this type of engine is that it is a lot of power wrapped up in a small package.

The large heavy type is preferred on heavy rigs working on deep holes. In this kind of drilling, the job lasts a considerable time, frequently months. Moving the heavier machine is not a serious problem as moves are not frequent. Being built heavy and operating at low rpm and low bmep, these engines are among the most economical engines today. The only engine comparable from the standpoint of economy is the spark plug engine fueled with low priced natural gas. And this type fuel is not always available, especially in wildcat drilling.

The second type, because of its low unit weight and low weight per bhp is well suited to blitz rigs and rigs working in shallow fields where moves are frequent. Their operational cost per bhp day is not so good as heavier engines but they have increased flexibility and maneuverability.

Diesel Lubrication. Lubrication of diesels poses a little more difficult problem than lubrication of spark plug jobs. The compression ratio being higher, blow by is harder to prevent. Using a heavy fuel there is greater formation of carbon and dilution of crankcase because of fuel oil leaking past the piston rings. Frequently diesel fuel is found to contain sulfur. This of course creates sulfuric acid in the crankcase unless the crankcase temperature is kept high.

Diesel lube oil today is an additive or detergent oil. It is usually manufactured with 3 levels of detergency. For use with a good fuel on normal loads an oil with 5 per cent additives might be satisfactory. An oil containing 10 per cent additives is generally considered better. If bad fuel is used in conjunction with heavy loading, an additive content of 20 per cent may be advisable. If there is a question of doubt, get a good lubrication engineer to advise you.

As can be seen from the above, oil changes must be quite frequent. Some operators change oil as often as every three days. Few go longer than a week between changes.

Dual Fuel Carburetion. This type of fuel control allows a diesel engine to operate on 100 per cent diesel fuel or part diesel oil and part natural gas. Theoretically a mixture containing 10 per cent diesel fuel oil will give combustion within the cylinder, that is, will produce the diesel cycle. Actually a diesel explosion may be produced with as low as a 5 per cent diesel oil content. The desirability of such a fuel arrangement would be on a drilling rig that might be drilling one month in a field where low priced gas was available and the next month out on a wildcat where no gas was to be had.

The first dual fuel engine the writer had a chance to inspect was a heavy duty compressor of 1000 bhp. A single control wheel was used. Turning the wheel in one direction opened the oil line and at the same time pinched down on the natural gas. Turning the wheel in the opposite direction reversed the procedure. About two years ago we decided to try a dual fuel setup on a diesel driven mud pump. This fuel arrangement had two separate valves, one on the gas line and one on the diesel fuel line. In starting up the engine cold, it was necessary to start with 100 per cent diesel fuel. After the engine was running, the gas valve could be opened and the diesel valve closed, this valve being adjusted so that when closed sufficient oil entered the cylinder chamber to produce diesel combustion. Results on test runs were very satisfactory. The principle and method of operation was explained to the operating personnel and the pump was installed at a well. Engine trouble immediately developed and continued without abatement. Watching the job soon showed the trouble. The crew members were consistently neglecting to close the fuel oil valve when opening the fuel gas valve, resulting in a terrifically rich mixture. No amount of explaining and instructing did any good. Finally in self-defense this system was removed and the regular diesel fuel system reinstalled.

As a result of this experience, it would appear that dual fuel carburetion could be made to pay dividends in many cases provided the mechanical design was such that the personnel element could be eliminated.

At least one drilling engine manufacturer is getting around the above problem by changing the engine accessories. If it is desired to change from diesel fuel to natural gas, the 15 to 1 compression ratio cylinder heads are removed and replaced with heads of around 7.4 to 1. Larger engines usually having a lower ratio than the smaller ones. Also fuel pumps and injectors are removed. An intake manifold, natural gas carburetor, and magneto are then bolted in place.

One mechanic with helper should be able to make this

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Skid-mounted diesel engines and DC electric generators.

conversion on one engine in about one 8-hour day. To make this possible, each engine comes with a kit containing all accessories necessary to change over to natural gas.

The kit box is designed to handle either diesel or natural gas accessories. In this manner, the parts not in use are stored and safe from loss or breakage until a reconversion is necessary.

Successful operation of a diesel engine depends on cleanliness of fuel more than any other one thing. Tanks and drums must be clean. Hoses used in transferring fuel must especially be watched. Temperatures must be kept the same as on spark plug engines. Torque converters are also a must on the diesel for smooth operations.

DC Electric Drilling

When speaking of electric drilling, one naturally thinks of DC current because of its ease of handling, smoothness, flexibility, and speed. This power, like the torque converter equipped combustion engine very closely approaches steam in its desirability for oil well drilling.

In considering DC electric drilling one is at first inclined to think of it as being divided into two distinct types of power, that is, engine driven electric or as it is sometimes called, diesel electric and AC-DC or all electric. Actually this is a minor sub-division. In either case your DC current must be generated on the job. The same generators are used, same motors, switches, and controls. The only difference is in the source of power used in driving the generators. This power may be gas-gasoline or diesel engines, AC motors or even steam turbines. The type of power selected to drive the generators is principally a matter of economics. To get reliability, it is necessary to have more than one generator. Four or five is the usual custom, otherwise your eggs are all in one basket. A failure of this generator or driving power might leave the drill stuck on bottom with an expensive fishing job ahead.

To get reliability on an AC-DC job, it is necessary to install combustion engines as a stand-by in case of power failure. This stand-by power should be approximately 50 per cent of the AC motors. It is not necessary to install stand-by generators with the engines. Since each AC motor and generator will probably be a direct drive skid mounted job, the skid can be lengthened and the engine mounted on the skid and in line with motor. The engine power take off can be connected to the AC motor by a positive clutch. In case of power failure, the engine would drive the generator through the motor shaft with a minimum of power loss between engine and generator. Each generator will require a variable voltage exciter. This generator can easily be mounted on top of the main generator and driven by V-belts off the main generator shaft.

All DC motors will require forced draft cooling. This can be obtained by mounting a blower on top of each motor and using V-belt drives off the motor shaft. Explosion proof motors will be necessary as all are in close proximity to the well. Open motors, however, can be safely used by installing an air duct with a flexible air tube from the main tube to each motor. Air would be forced through the duct by a fan installed in intake end of duct. The intake naturally must be at a safe distance from the well so as to insure hydrocarbon free air to the motors. The motors driving the draw works and mud pumps will be quite large, several hundred horsepower while the motor driving the mud mixing pump will be small, probably not more than 100 bhp. To get maximum efficiency, this motor should be hooked up to take power from the generator powering some other piece of equipment, such as the rotary table. This way, mud can be mixed while rotating without in general, interfering too much with drilling operations. If, on the other hand, an entire generator must be segregated to operate this small pump, a mud pump will be taken out of operation with frequent undesirable results.

One thing to remember about an electric rig is that many magnetic switches are necessary. These switches are used so frequently as to create a case of mechanical abuse. Automatic shut down switches should be placed at the derrick top to prevent the traveling block running into the crown in case of control switch failure. The saline action of ocean air would probably aggravate the switch condition on an electric rig working on the beach or in off shore drilling.

The all electric rig is restricted to areas served by reliable high tension energy. The engine driven electric rig has no more restrictions than any combustion engine powered job. All generator assemblies, transformers, motors, and pumps may be mounted on skids and/or dollies that facilitate moving and rigging up. This provides a definite saving over steam rigs the same as is the case with combustion engine power. Very few DC electric rigs are in operation today compared to the many combustion engine powered rigs to be found in all fields. Not much data is available regarding them. Performance of the few in operation, however, is such as to warrant consideration when purchase of new drilling equipment is on the fire, even though the first cost is higher than other types of power.

AC Electric Drilling

In the past some experimental work has been done with AC drilling. A few such rigs have been built using current from high voltage public utility lines. The writer has had no contact with such equipment so cannot comment on it. We do know, however, that further experimental work is being done with this type of energy. The difficulties inherent in an AC rig when compared to DC power are such as to detract from its apparent feasibility. The progress of technology, however, is such as to make it inadvisable to say this or any other power is impossible.

In the final wash, the type of drilling power most satisfactory is a matter of economics. The only place where the above is ruled out is when drilling is to be done where no AC electricity is available. Here the all electric rig cannot be considered. Engine power must be the source of energy, whether it be applied to the drilling rig through torque converter or DC current. In all cases, the type of engine most desirable will depend much on the type and price of available fuel. This then becomes a matter of economics.

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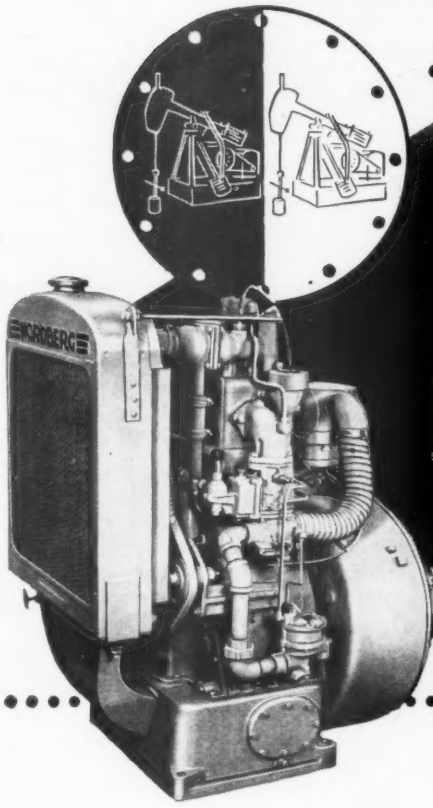

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Drillers and Tool Pushers

Keys To Profitable Drilling Contracts

Management ability is basic factor needed in drillers and tool pushers if contractor expects to remain in better than average economic position

WILSON J. BENTLEY

WHAT really determines the value of a driller or tool pusher in a contractor's organization and operations? Obviously, a number of things are considered in establishing his rate of pay. These include the "going rate," the man's experience, and the availability of qualified personnel.

The real basic factor in establishing his worth to the organization, however — and this should never be overlooked — is his ability to make his company competitive with other similar companies.

The word "competitive" here refers to efficient operation in all phases of drilling, including:

(1) Length of time it takes to tear down
(2) How well the equipment is maintained
(3) How well the equipment is used
(4) Amount of time the bit is on bottom
(5) Choice of time to make a trip
(6) Choice of bits to use
(7) Use of crew's time when not making a trip and
(8) Effective utilization of the crew's efforts at all times

There are many other phases to consider, but these rank as the more important. Reflecting on the phases of drilling pointed out above, it can easily be seen that a supervisory employee's worth to a contractor depends on his:

Judgment,
Technical Ability, and
Economic Utilization of Men and Equipment.

Judgement. One could say that judgement is the ability to make decisions, which, based upon conditions, are most likely to be correct. How does one acquire "good judgement?" It probably results from (1) education (either school or self-education), (2) experience (both good and bad), and (3) native intelligence.

Not much can be done about native intelligence, but every normal person is born with enough of it, and it is a valuable property provided it is properly used.

Using experience in making decisions depends on proper thought and analysis of past occurrences. For instance, none of us go after a "left-handed" wrench but once. We have analyzed that situation properly.

Formal education is something that has been easy for some to obtain, although for others circumstances have prevented its acquisition. Books and magazines, however, are available to everyone, and the individual need never quit learning through this medium. Some of America's most successful and valuable citizens are self-taught.

Technical Ability includes the ability and knowledge necessary to use and maintain equipment entrusted to the care of the driller and tool pusher. It also indicates an understanding of the functioning of the equipment in relation to the job it should perform. As with judgement, technical ability results from education, experience, and native intelligence.

Economic utilization of men and equipment indicates a knowledge of how to get the most results with the least total effort, and with the safest, easiest, and quickest methods. This, again, is a result of education, experience, and native intelligence.

What happens if these three—judgement, technical ability, and economic utilization of men and equipment—are implemented in drilling a well?

The contractor is placed in an economic position where he can get more drilling contracts and make more profit per well. More drilling contracts result in steadier work, which means more total income for the individual. More drilling contracts and more profit mean higher wages and better equipment.

EXCLUSIVE

Applying the Factors

All these factors boil down to one basic premise—control of costs. Let us consider how this factor is important to successful operations, and in making the driller or tool pusher's services successful.

Costs. Success of the driller and of the tool pusher is largely measured by the cost of operation in relation to the conditions under which a well is drilled.

Attitudes are important. The general attitude of the tool pusher or driller about a job is reflected in the attitude of the crews. What he says, how he says it, what he does, how he does it, and how he thinks—these are all determining factors in crew attitude, welfare, and teamwork.

Cooperation. The tool pusher has great latitude in influencing cost controls, and because of this latitude, must recognize this responsibility. He cannot control costs alone, though, and it must be through the help and understanding of the drillers (and individual crew members) that he perform this function properly.

Buying. The tool pusher does a great deal of buying as the result of his own observation of the needs, and also at the suggestion of the driller. He is obligated to buy wisely.

Communication. Purchases are usually reported on purchase orders. These orders should contain the details of why the object was purchased. They are important for accounting records, billing on contracts, and for proper handling in the main office. Most important of all, details are necessary in

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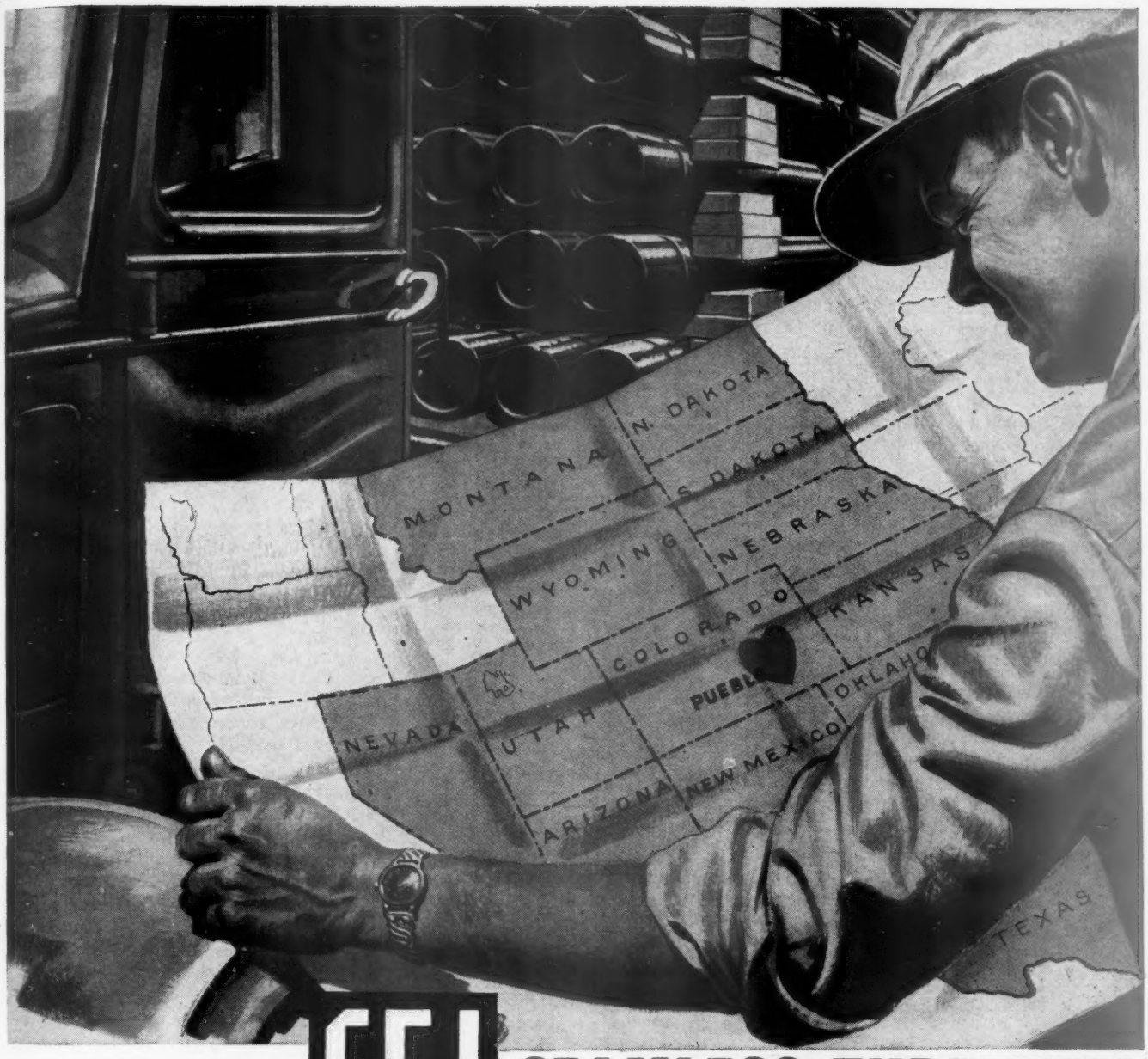

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order for top management to fully understand the purchase. Top management, to run the business, must have an accurate picture of field conditions.

Economic pay-out. With each purchase, the intelligence of the tool pusher is tested. He should not ordinarily buy just to "have it on hand" or because "we might need it some time," or because it is a "new fangled gadget." The purchase should have economic use and should be purchased on an economic pay-out basis, or for absolute maintenance to keep the rig running. If the driller understands this, he can better understand the problems of the tool pusher. If the tool pusher understands it, he will be fulfilling another management responsibility.

Time vs. Cost. As the name implies, the tool pusher's objective is to crowd the job to "make hole," finish in the best possible time at the lowest cost. The tool pusher and the driller must continue to try to do more with less time and less costs. It must be remembered, however, that time saved at higher costs is not the goal sought.

Job Planning. From past discussion it can be seen that the over-all picture is a balance of time against costs. Purchasing is a part of the job planning—which is a part of cost planning. The tool pusher and the drillers must try to increase drilling speed without loss from work stoppage. Preventive maintenance thus becomes an important factor. Breakdowns, stoppages, expensive repairs, probing jobs, and all other troubles must be avoided if possible.

Depreciation. Depreciation is a part of real costs. The way the tool pusher handles his men and equipment and the way the drillers handle their men and equipment determine the real depreciation costs.

Interpreting Policy. It is top management's responsibility to communicate its policies to the employees. The tool pusher and the driller interpret and implement these policies (bearing in mind the basic intent of the policy makers).

Small Costs Get Big. As the tightening of the competitive situation becomes more acute, the responsibilty of the tool pusher for tighter control of costs multiplies. Small cost items become important. A broken sack of mud, loss or breakage of hand tools, or failure to properly use oil or grease are signs of waste. A hammer, dropped on the ground around a rig and not picked up within 30 minutes, is a lost tool. It is either covered up by something within that time or a truck runs over it and buries it. At current labor rates, a four man crew costs a company approximately 13 cents for every minute they are on tour. A waste of their time costs the drilling contractor, the oil company, the public, and (in the long run) the men themselves.

Carelessness. This can originate anywhere in the organization. The job of management is to recognize it as soon as possible and apply the specific remedy. Somebody kicks a wrench in the hole, makes an improper connection, or breaks the head off a hammer and flings it as far as he can—these are signs of morale deterioration that the driller or tool pusher must recognize and take appropriate action. Of course, giving credit for a job well-done must never be forgotten.

Practical Psychologists. Tool pushers and drillers must also become practical psychologists and build cooperation for mutual welfare. If a crew's morale appears to be lowering, they should attempt to find the cause and apply the remedy. They must be able to recognize individual short-comings, resolve differences, and build harmony in the crews.

Public Relations. Tool pushers and drillers are the most important public relations representatives that a contractor has. They have direct contact with the public. The public's attitude toward the company is formed by what it sees and what it hears. Respect for the landowner's rights can be shown by keeping all trucks on only the necessary roads, seeing that cattle gates are kept closed, hauling cans and other refuse away rather than throwing them in the pond or the field, and by saving the farmer's crops.

Disregard of these and other common courtesies costs in money or prestige, or both. Control of these policies is a direct responsibility of the tool pusher, and in turn, the drillers.

Conclusions

The public and the contractors are voicing an increasing demand for wells drilled at less cost while at the same time, the cost of supplies, labor, and equipment continually rise.

It isn't the purpose of this discussion to attempt to determine why this is happening. It must be admitted and let stand at that point. The challenge must be met—or the contractor is likely to go out of the business. None of them desire to do that.

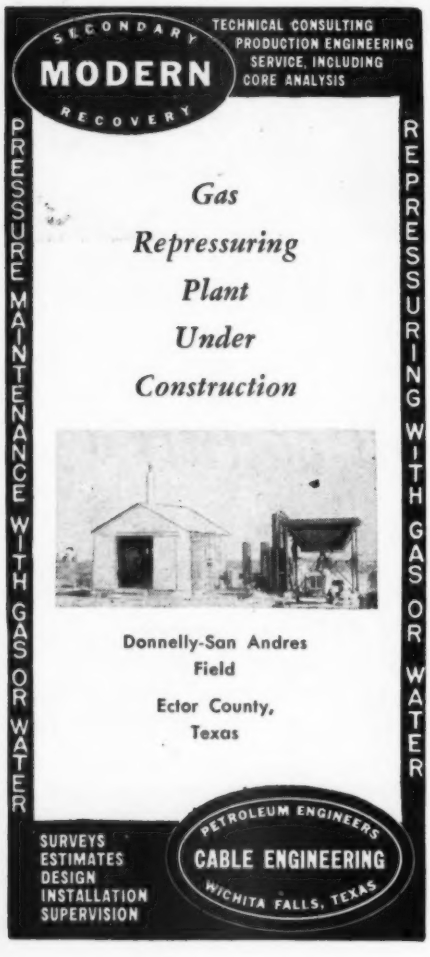
A company can be competitive if every driller and tool pusher constantly question every proposed purchase, every time-taking activity, every trip made, and seek to improve their supervisory qualities.

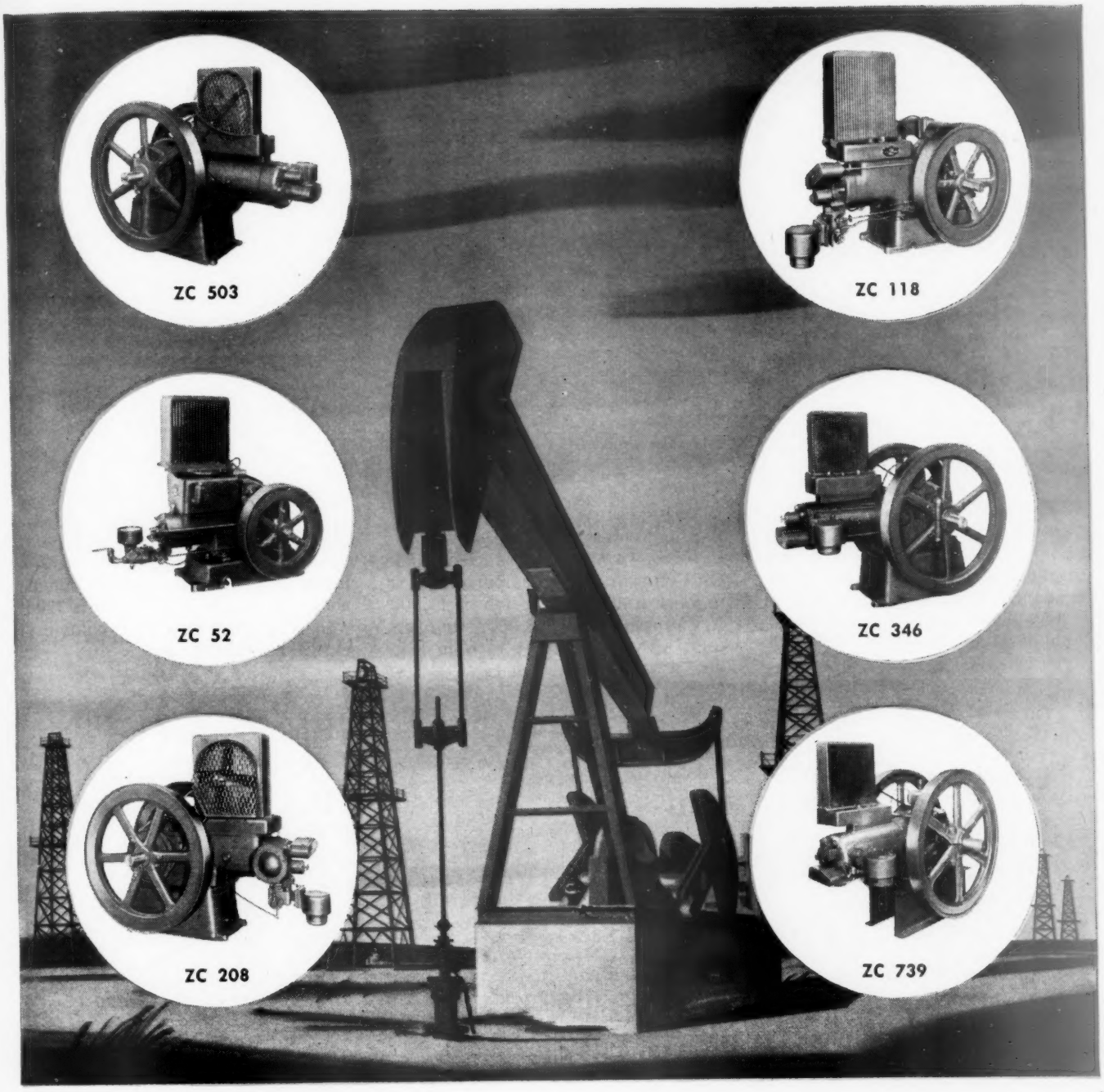
The size of both his and his company's income is primarily dependent upon how competitive his company becomes. * * *

The Author

Wilson J. Bentley is associate professor of industrial engineering and management, Oklahoma A. and M. College. He has BS and MS degrees in industrial engineering from Oklahoma A. and M. College. In addition to his teaching experience he has spent a year in electrical construction work and five and a half years as an army engineering officer. Following World War II he was a planning and methods engineer for Wilson and Company for three years, and refinery industrial engineer of the Deep Rock Oil Company in excess of a year.

He has served in a consulting capacity to numerous industries (including oil refining, production, and drilling) in the field of management, methods study, and job evaluation. He is currently on a retaining basis with a small manufacturing business. Bentley is a registered professional engineer in Oklahoma, a member of Oklahoma Society for Professional Engineers, National Society for Professional Engineers, a member of the American Institute of Industrial Engineers, a member of the American Society of Engineering Educators, and a member of the National Panel of the American Arbitration Association.





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XUM

WHAT'S DOING IN DRILLING

KANSAS

★ Cities Service reports a one-quarter mile extension of the Willowdale pool of Kingman County, Kansas, in the completion of its confirmation well, Mueller C No. 1.

Well is a southeast diagonal offset of the Aurora-Amsden No. 1 discovery and established a potential at the daily rate of 3295 bbl from perforations in the Viola from 4473 to 4490 ft. Drilled to a total depth of 4660 ft, the well was plugged back to 4509 ft. Extension is approximately 17 miles southwest of Kingman. Cities Service is in the process of completing 2 additional wells and drilling 2 others.

NEW MEXICO

★ In the Anderson Ranch unit, Lea County, Unit Well No. 15 has been drilled to a depth of 10,003 ft by Continental Oil Company. Drillstem test at 9629-9850 ft in Wolfcamp flowed 72 bbl of oil in 1 hour.

★ Cities Service has given the Drickey-Queen pool of Chaves County New Mexico, a ¼ mile north extension in the completion of its State AN No. 1 for a flowing potential of 492 bbl of oil daily.

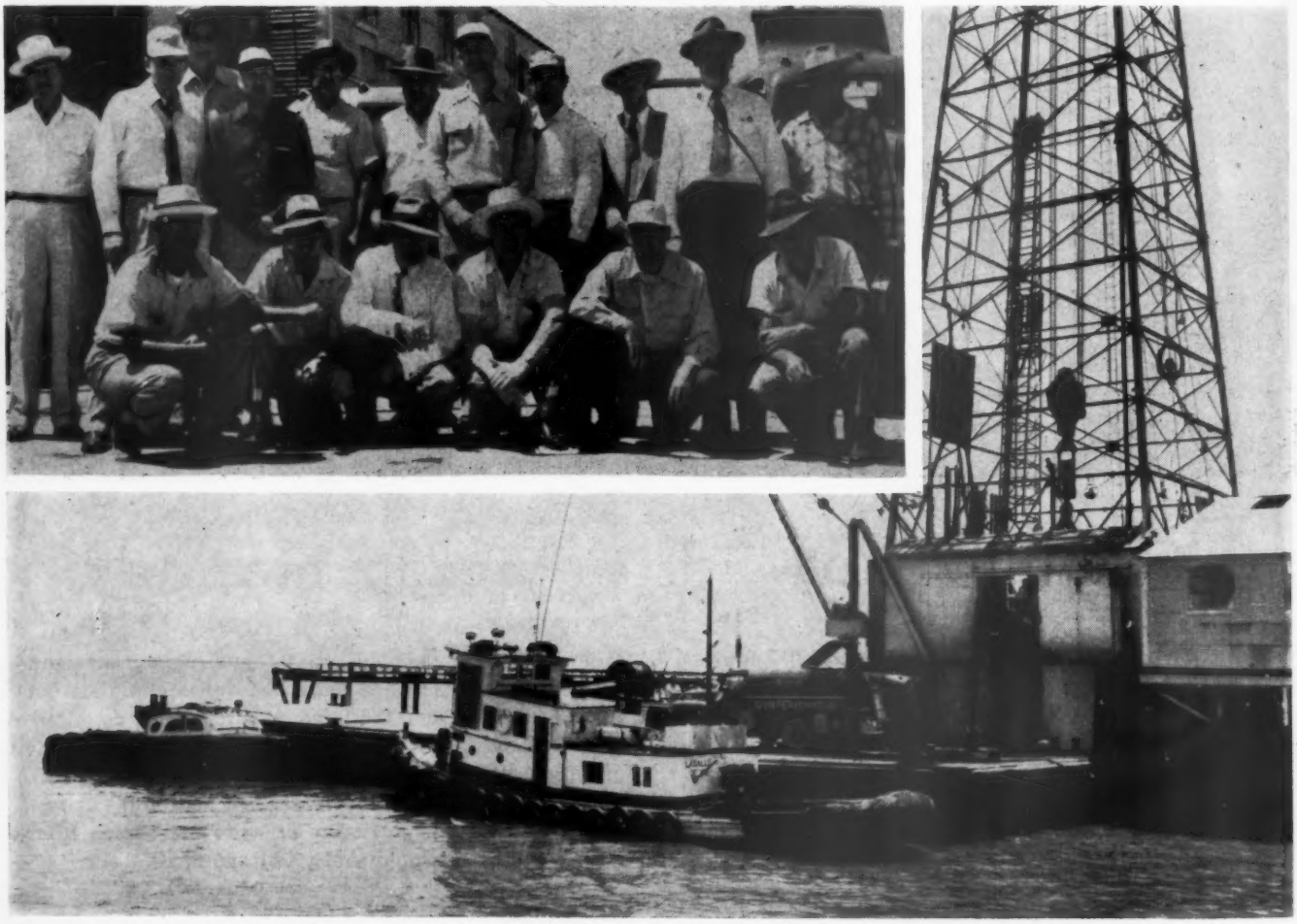
Well flowed 82 bbl of oil, no water, through 2-in. tubing during a 4-hour potential test. Total depth is 3062 ft and the Queen sandstone was topped at 3042 ft. Extension is in the center SW SW, Sec. 2-14s-31e, approximately 30 miles northwest of Lovington and 5 miles southwest of the Caprock field. Cities Service has a 3500-acre drilling block in the field.

TEXAS

State of Texas Tract 393 No. 1, Laguna Madre area, Kennedy County, has been completed by Continental Oil Company. Well was plugged back to 9441 ft after total depth of 13,000 ft. Casing was set at 13,000 ft and perforations made at 9404-34 ft in Frio sand. Well flowed 2,500,000 cu ft gas and 25 bbl of distillate through a 12/64-in. choke. Open flow potential is 20,000,000 cu ft gas. Shut in tubing presssure, 3900 lb.

★ A one-quarter mile extension of the South Cowden-Ellenburger pool of Ector County, Texas, was reported by Cities Service in the completion of its joint interest Foster E No. 1 for a daily potential of 760 bbl of oil.

Well is ¼-mile southwest diagonal offset to the company's joint interest TXL "K" No. 1 discovery well and flowed 412.57 bbl in 13 hours from perforations in the Ellenburger from 12,913 to 13,000 ft through ¾-in. choke after acidizing. Flowing tubing pressure was 200 lb and the gas-oil ratio 970 to 1. Drilled to a total depth of 13,118 ft, water level was established at 13,100 ft. Total oil column above water in Foster E No. 1 is 190 ft which confirms a total oil column in the field of 285 ft.



McCullough Tool Company's new tug and barge which will be used in Louisiana for offshore duty. McCullough crews are in the process of radiation logging and perforating a Texaco well on Texaco's drilling barge "Chandler" located in Lake Pelto. (Insert) McCullough's Los Angeles and eastern division personnel aboard McCullough Tool's new barge. Standing: Bill Perkins, Nate Erwin, Bob Smith, Dick Casterline, Jack Marler, W. S. Reynolds, Herman Schaller, J. J. McCullough, H. E. Hester, D. J. Hall, and John Cooper. Kneeling: K. K. Campbell, O. E. Petty, A. D. Beman, M. L. Van Wagner, Ed Zareh, and John George.

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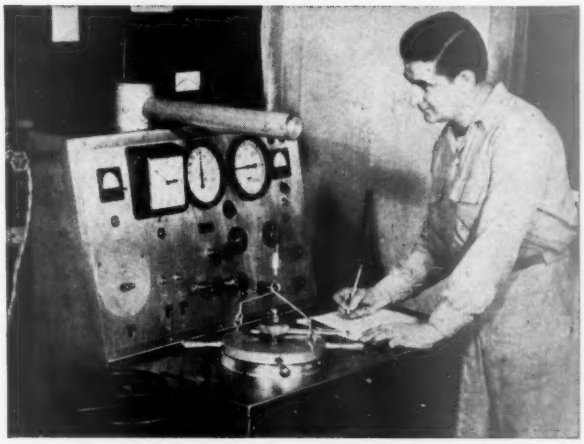

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XUM

Rotary Rigs Operating in Oil Fields of United States and Canada*

	July 5	July 12	July 19	July 26	Aug. 2	Aug. 9
Pacific Coast	130	123	121	121	120	120
Oklahoma	291	303	281	307	310	328
Kansas	173	168	169	164	157	168
Rocky Mountains	252	249	253	256	263	255
Canada	140	151	148	167	178	157
Ark-La-Tex	176	176	176	158	155	163
West Texas and New Mexico	493	485	468	455	456	456
Gulf Coast	534	542	546	544	546	536
Illinois	147	135	141	122	115	114
North Texas	333	324	310	295	316	313
	2669	2656	2613	2589	2616	2610

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

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TEXAS

★ The British-American Oil Producing Company of Dallas, Texas, has completed its No. 1 TXL "K" located 20 miles SSE of Sweetwater in the NE SE Sec. 15, Block 2, T & P RR Company Survey, in the E. A. Cambrian field of Nolan County.

On potential test the well flowed 285 bbl of 50 gravity oil per day through ¼-in. choke from the Cambro-Ordovician dolomite section at a depth from 6030 to 6082 ft after treatment with 1000 gal of acid. Gas-oil ratio is 574 CF per barrel. Core analysis indicates a total of 85 ft of effective pay.

★ A one-half mile northeast extension of Spraberry sandstone production in the Flat Rock pool of Upton County, Texas, was reported by Cities Service in the completion of its joint-interest University AQ No. 3 at a daily rate of 725 bbl of 36 deg oil.

Well flowed 151 bbl of oil in 5 hours from Spraberry perforations from 7124 to 7147 ft through ¾-in. choke after sandfrac. Flowing tubing pressure was 150 lb and the gas-oil ratio was 850 to 1. Well had been drilled to the Ellenburger at total depth of 11,086 ft, then plugged back to the Spraberry.

Extension is located 1980 ft from the south line, 660 ft from the west line, Sec. 30, Block 3, U.L. survey.

LOUISIANA

★ Continental Oil Company has completed the Maple Hughes No. 1, Lake Arthur field, Jefferson Davis Parish, to a total depth of 9220 ft. Casing was set at 9197 ft and perforations were made at 9084-9110 ft in Clavulina sand. Well was flowing 3,140,000 cu ft gas and 35 bbl of distillate through 12/64-in. choke. Tubing pressure was 3500 lb, shut in tubing pressure, 3700 lb, and gravity 50.6 deg.

★ With the completion of its Miami Nos. 16, 17, and 18 as gas distillate producers, Pan American Production Company is temporarily suspending development of its large South Pecan Lake gas distillate reserve in southeastern Cameron Parish. Additional drilling is planned for next year. Last 3 wells have all been dually completed. Miami No. 16 flowed 44,000,000 cu ft per day from the A-1 zone at 7700 ft and 50,000,000 cu ft per day from the A-2 zone at 8250 ft, Miami No. 17 flowed 52,000,000 cu ft per day from the C-1 zone at 10,500 ft and 25,000,000 cu ft per day from the C-6 zone at 12,300 ft, and Miami No. 18 flowed 30,000,000 cu ft per day from the B-2 zone at 8800 ft and 35,000,000 cu ft per day from the B-3 zone at 9900 ft.

South Pecan Lake, discovered in October 1951, is one of South Louisiana's major gas reserves.

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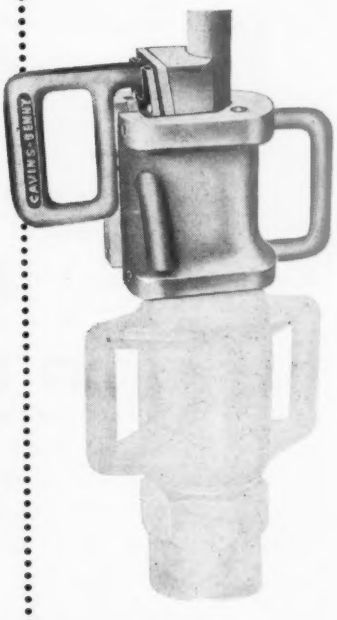

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OKLAHOMA

★ Continental Oil Company's Fletcher-Dotson No. 1, Camp Tussy pool, Carter County, has been dually completed for an IP from the Fusulinid of 456 bbl through a ¼-in. choke, and from the Tussy at 427 bbl through a 20/64-in. choke. Well was plugged back at 4772 ft after drilling to a total depth of 4806 ft. Casing was set at 4805 ft and perforations were made at 8 intervals in the Fusulinid and Tussy. Casing pressure was 600 lb, gravity, 30 deg. Tubing pressure was 300 lb.

★ Sunray Oil Corporation has completed the third successful oil producer in the Northwest Trimue pool, a new exploratory development in Tillman County, southern Oklahoma. The company's No. 1 Alexander, SE SE NW Sec. 3-3S-19W, is flowing at the rate of 115 bbl of oil per day on 18/64-in. choke, tubing pressure 115 lb.

The new Sunray well is a west offset to the field discovery well. It is drilled to a total depth of 5070 ft and perforated 4968-77 and 4996-5003.

★ Vickers Petroleum completed in the Springer sand at its No. 2 Crawford in Southwest Panther Creek, Garvin County. Well flowed 685 bbl of oil in 28 hours through a 28/64-in. choke. Perforations were at 9645 to 9674 ft. Total depth was 9800 ft.

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CANADA

★ Canadian Bishop Oil, Ltd., has spudded its Pembina Number 16-21 well on a recently acquired 160-acre Crown Lease in the Pembina oil field area of Alberta Province, Canada. Anticipated total depth is 5350 ft. Well is ¼ mile north of a fully equipped Cardium oil well which is temporarily shut-in pending completion of a pipe line to the field.

★ Pacific Petroleums Ltd. and Associates report that Pacific Fort St. John No. 38 well, approximately 16 miles northwest of the town of Fort St. John, British Columbia, obtained strong gas flows on drillstem tests from the Triassic "D" zone sand.

Test from 4990-5005 ft received gas to surface in 5 min. Test from 5005-25 ft had gas in 2 min. Test from 5025-53 ft received too small amount of gas to measure.

With casing set at 4964 ft, well will be completed open hole, with expectations of nitro-glycerin being employed later.

Pacific Fort St. John No. 38 is a 3-mile step-out from No. 36, and it is planned to make another 3-mile step-out for No. 39. This is the third well in the Red Creek field, with each well a step-out of from 3 to 3½ miles from the previous location. Each well has been completed in the Triassic "D" zone. An estimated 40 ft of productive sand in this zone has been penetrated.

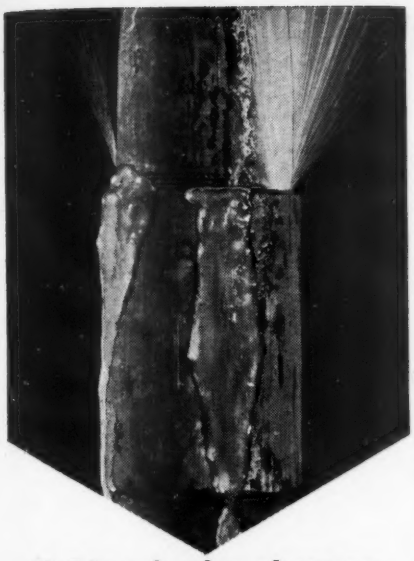
MONTANA

★ A fifth successful Moulton sand completion for Ponder Oils Incorporated, 9 miles west of Sweetgrass, has been announced. Field reports indicated the well, Pattie Stewart-State No. 5, which flowed initially at 55 bbl of 40 deg oil an hour, was giving up oil by heads at a rate of 30 bbl an hour. Top of the productive sand was contacted at 2682 ft and bottom of hole was made at 2710 ft with 31 ft of effective pay zone in between. Production casing was set to a depth of 2683 ft and the rig was skidded south for a start on Pattie Stewart State No. 6.

Well is in Toole County.

Useful Tool

American Steel and Wire has designed and has available, for the use of the industry, a very handy and simple to use ton-mile calculator. Constructed of heavy cardboard in a circular shape, the instrument gives a direct ton-mile calculation for trips up to 20,000 ft with either 3½ or 4½-in. drill stem and considers both block and hook weight and buoyant drill collar weight.



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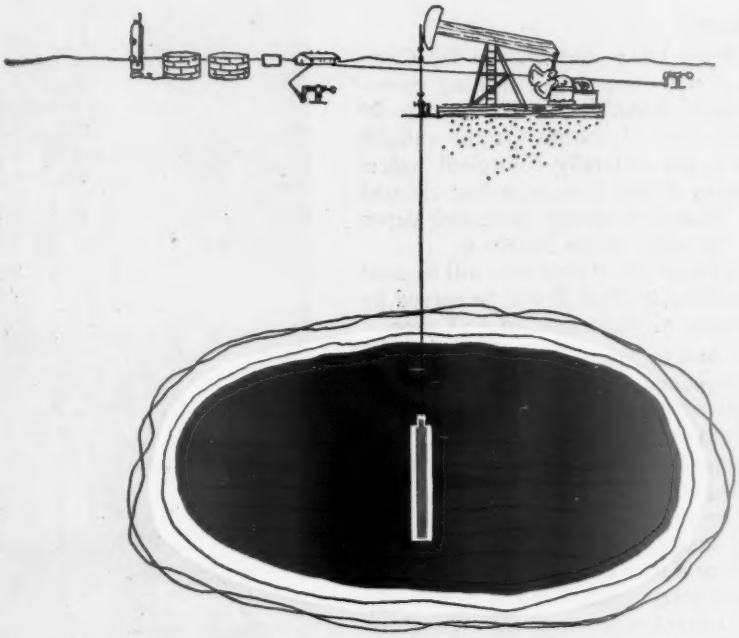
Water Flood



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ROD PUMP

EXPLORATION ACTIVITIES

NEVADA

★ Shell Oil Company will drill a third well in Nye County, Nevada, site of the state's first oil discovery last winter.

The new well, the No. 2 Eagle Springs unit, will be about 9 miles southwest of the discovery well. The company's second attempt, about 5 miles south of the discovery well, proved dry and was abandoned at 6038 ft.

TEXAS

★ Pure, Ohio, and Melben Oil Company will soon begin drilling operations off of the Texas coast in 55 to 60 ft of water. Location for the venture lies in the federally controlled waters outside of the 10½-mile line claimed by Texas. Presently projected depth for the test is below 10,000 ft.

A 70 by 106 ft structure will be used in drilling the test. It will be served by a tender of the converted LST type.

★ Cities Service is locating a test well in Henderson County, Texas, on its 4600-acre block, 9½ miles southeast of Athens, Texas, with the nearest production being 8 miles northwest in the Blackfoot pool.

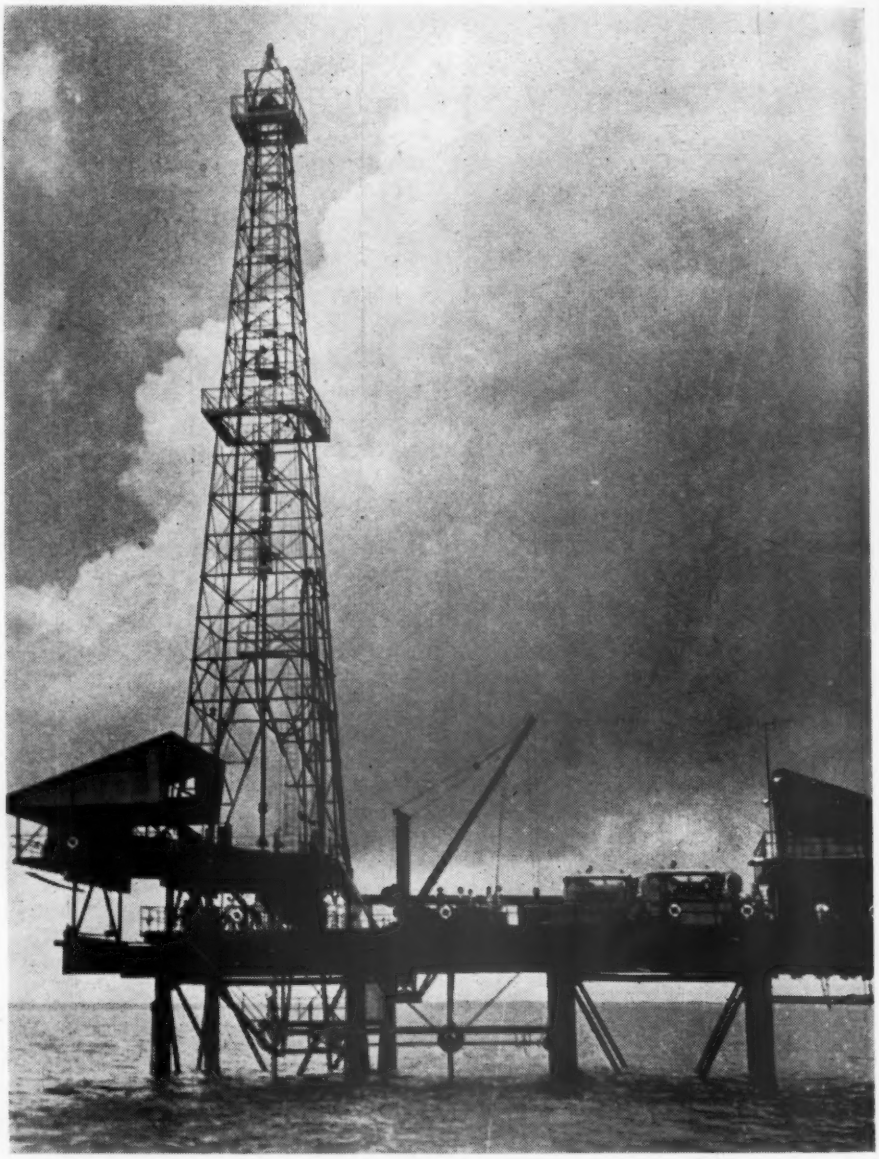
The Briggs No. 1, is located 330 ft FNL and 330 ft FWL of Block 28, Phillips Jackson Survey, A-392. Projected total depth is 5800 ft into the sub-Clarksville and the Woodbine sand.

★ A new wildcat oil discovery well flowing at a potential rate of 396 bbl per day in Stonewall County, Texas, has been announced by Sunray Oil Corporation. The new well, Sunray's M. C. Johnson No. 1, is three-quarters of a mile from production in the Flower field, and the completion may be a northern extension of this field, southeast of the town of Aspermont.

Well was completed to total depth of 4270 ft, and is producing from the Canyon series, having penetrated 42 ft of producing pay sand. The oil is 38.5 gravity, gas oil ratio 456 to 1, tubing pressure, 70 lb.

Sunray has staked location for an east offset.

★ One new Caddo has been opened in North Texas. D. G. Gordon of Breckenridge, Texas, completed the No. 1 G. R. Lunsford as a Caddo discovery in Throckmorton County, 8 miles southeast of Throckmorton. Well flowed 310 bbl of 43 deg oil per day through 14/64-in. choke from perforations at 4098-4108 ft.. Casing was set at 4339 ft, total depth. Gas-oil ratio was 640-1, tubing pressure 480 lb.



Trinidad Northern Areas Limited's platform and rig on site of company's first offshore well. Site is six miles from Credos Point off the southwest coast of Trinidad.

★ Humble Oil and Refining Company and Continental Oil Company have completed a Fusselman discovery in Crockett County. The No. 1-AB University was tested for a daily flowing potential of 114 bbl of 44.6 gravity oil, with gas-oil ratio of 589-1.

Production was through a 14/64-in. choke from perforations between 9240-9290 ft in 5½-in. casing. Top of the Fusselman was picked at 9240 ft on elevation of 2606 ft. Pay section was acidized and fractured.

★ Superior Oil Company has a gas-distillate discovery on an 1800-acre block in Galveston County. The Cooper Unit No. 1 flowed 325 bbl of 41.4 gravity distillate and 5,750,000 cu ft of gas daily from casing perforations between 11,686 and 11,694 ft.

INDIANA

★ Sun Oil Company has a new discovery in Posey County, southwestern Indiana. The No. 1 Massee had the Cypress sand from 2296 to 2303 ft and on test made 3 bbl of oil an hour natural, 14 bbl after fracturing.

FLORIDA

★ Gulf Refining Company plans a 12,000 ft Sunniland lime test in the Forty Mile Bend pool of Dade County, in extreme southern Florida. It will be No. 2 State of Florida-340, C SE NW 19-54s-36e. Tri-State Drilling Company has been given the drilling contract.

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XUM

Exploration

CALIFORNIA

★ Shell Oil Company has moved a contract rig into the Carrizo Plain area in San Luis Obispo County, where they will drill another wildcat on Sec. 22, 30-19. During the past 6 years over 50 dry holes have been drilled in this area without achieving commercial production.

★ Humble Oil & Refining Company is preparing to drill Humble-Intex- Lerdo No. 1 on Sec. 4-29s-27e in Kern County. The location is north of the Fruitvale field and three miles east of Rosedale production.

★ Aeco Corporation in a joint venture with British American and Shell will drill a wildcat northeast of the Russell Ranch field in Cuyama Valley. The location will be on Sec. 13, 11n-28w where they plan to drill to depth of 7500 ft to test the Dibblee, Colgrove, and Soda Lake formations.

★ Burt Aston has made a new and significant oil discovery at Sunset Beach in Orange County. It has a reported potential of 600 bbl per day of 29 deg oil, producing through a 24/64-in. choke. The well was originally drilled to 8707 ft and then redrilled to 7185 ft.

CANADA

★ Sapphire Petroleums Limited is now rigging and preparing to spud in a wildcat in the east Kirkella district of the Virden area of southwest Manitoba. It will be the first of 12 wildcat wells Sapphire will drill in the Virden area this year. It is expected that the well will be drilled to approximately 3200 ft.

Sapphire will serve as an operating company on the project.

WYOMING

★ Sapphire Petroleums Limited has announced the drilling of two 10,000 ft test wells to the Shannon sand in Wyoming's Powder River Basin. The wells are located on 2 separate tracts in the Powell area of Converse County.

NEW MEXICO

★ Wilshire Oil Company of Texas' No. 12-30 Federal, east Lea County, and nearly on the west line of Gaines County, has been completed as a Wichita-Albany discovery.

Well flowed 291 bbl of 37.5 gravity oil daily on potential test. Gas-oil ratio was 1145-1. Production is from perforations at 7248-68, 7275-85, 7294-7324, 7330-50, and 7358-7418 ft.

★ Humble No. 1 Jicarilla, in west Rio Arriba County, on the southeast flank of the San Juan Basin, developed good shows in the Greenhorn lime from 6468-6508 ft.

Tested for 1½ hours, it surfaced gas in 13 minutes at the rate of 1,060,000 cu ft daily. Recovery was 50 ft of 58.6 gravity oil and 250 ft of heavily oil and gas-cut mud.

★ A new wildcat oil discovery in Lea County, New Mexico, has been announced by Sunray Oil Corporation. The new well, Sunray-Seaboard No. 1-B State, is 1¾ miles southwest of the East Caprock field and 2½ miles northeast of the Caprock field. Well was brought in with a pumping potential of 104 bbl of 36 gravity oil daily based on a 15-hour test, gas oil ratio 150:1 with no water.

The well, drilled to a total depth of 3025 ft, topped the Queen's sand at 3008 ft. Five and one-half inch casing was set at 3008 ft and the operators were 17 ft in the pay sand when the total completion depth was reached, with total depth of pay zone still undetermined.

★ In Noble County, Sterling No. 1 Rence is an extension of production in the North Sumner gas area. Well found oil saturation in upper Layton sand at 3132 to 3141 ft, and on drillstem test netted 600 ft of pipe line oil, with flow pressure of 250 lb and bottom hole pressure of 1270 lb. Following the running of pipe on this well, Sterling announced offset location of No. A-1 Rence, and No. 1 Garvis as second new location.

SICILY

★ Macmillan Petroleum Corporation reports that Aragona No. 1 was spudded in July 28, 1954, and was drilled ahead at 900 ft on August 2nd. This test well is located on Mediterranean Oil Company's (Gulf 65 per cent, Macmillan 35 per cent) Aragona-Licata permit. The drill site selected after nearly a year's seismic work is about ¾ of a mile northeast of the village of Joppolo near the town of Aragona, in the central seacoast area of southwestern Sicily.

Well is being drilled by the American International Fuel and Petroleum Company.

The American International Fuel and Petroleum Company plans to commence a deep test exploratory well on the Mediterranean Oil Company's Comiso permit around September 1, 1954. Permit was transferred to Mediterranean by McMillian.

Two successful wells have been drilled by the Gulf Oil Company's subsidiary in the Ragusa area about 1¾ miles east of the central-western boundary of the Comiso permit. These 2 wells, according to unofficial estimates, will probably yield 500 to 700 barrels per day of 19 to 23 deg gravity oil. A third well in this field is now being drilled by Gulf Oil Company's subsidiary near present production.

SUMMARY OF DRILLING ACTIVITY FOR JULY
(As Compiled By Rinehart Oil News Staff)

States	New locations		Wildcat completions			Field completions			Junked & abnd.		Temp. abandoned		Abandoned locations		Current active wells	
	Wc	Field	Oil	Gas	Dry	Oil	Gas	Dry	Wc	Field	Wc	Field	Wc	Field	Wc	Field
Alabama	3	2	0	0	6	0	0	0	0	0	1	0	0	0	3	0
Arizona	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Arkansas	8	55	1	0	16	32	0	18	0	1	0	0	0	4	12	25
Canada (Williston B.)	28	29	2	0	18	22	0	4	0	0	1	0	0	6	19	14
Colorado	48	39	4	5	62	38	3	18	0	0	3	0	4	0	42	33
Florida	9	0	0	0	4	0	0	0	0	0	0	0	0	0	4	0
Georgia	1	0	0	0	5	0	0	0	0	0	0	0	0	0	1	0
Idaho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Kansas	80	222	8	3	55	147	28	75	0	0	0	0	0	0	64	289
Louisiana	46	229	4	4	33	174	30	35	0	2	0	4	2	9	58	246
North	11	126	1	1	16	109	8	11	0	0	0	0	1	5	14	43
South	35	103	3	3	17	65	22	24	0	2	0	4	1	4	44	203
Mississippi	16	19	1	0	15	14	4	12	0	0	0	0	0	0	16	16
Montana	26	25	1	0	8	18	1	6	0	0	0	0	0	2	24	26
Eastern	3	2	0	0	3	2	0	0	0	0	0	0	0	0	10	6
Western	23	23	1	0	5	16	1	6	0	0	0	0	0	2	14	20
North Dakota	10	14	0	0	13	17	0	0	0	0	0	0	1	1	14	29
Nebraska	25	30	2	0	11	18	4	5	0	0	0	1	0	0	18	27
Nevada	0	0	1	0	1	0	0	0	0	0	0	0	0	0	3	0
New Mexico	15	92	1	7	16	58	71	4	0	0	0	5	2	2	52	125
Eastern	7	72	1	1	15	57	17	3	0	0	0	2	0	1	40	99
San Juan	8	20	0	6	1	1	54	1	0	0	0	3	2	1	12	26
Oklahoma	94	698	11	3	70	494	26	197	0	0	0	2	1	16	72	640
South Dakota	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Texas	556	1,422	89	18	373	948	87	270	1	1	9	17	1	68	450	803
East	40	66	0	0	29	29	19	11	0	0	0	0	0	0	33	84
Gulf Coast	43	106	4	2	27	64	10	27	0	0	0	1	0	5	46	119
North Texas	121	422	18	4	83	242	11	92	0	0	1	0	0	0	41	82
Panhandle	10	70	2	0	8	52	15	4	0	0	0	0	0	8	23	25*
South Texas	105	189	6	9	74	112	26	53	0	0	4	7	0	6	84	98
Border Co.	32	95	7	0	26	69	0	14	0	0	0	0	0	4	38	59
West Central	107	167	28	2	67	100	2	46	1	1	0	1	0	0	47	40
West Texas	98	307	24	1	59	280	4	33	0	0	4	8	1	46	138	296
Utah	12	0	0	1	2	1	0	0	0	0	0	0	1	1	25	8
Wyoming	39	58	7	1	19	78	1	12	0	0	1	11	2	7	52	80
Totals: Jan.	699	2,425	121	47	611	1,780	254	584	6	5	10	21	17	144	808	2359
Feb.	713	2,816	101	28	503	1,583	228	542	0	5	21	22	29	98	845	2362
March	975	2,945	115	42	585	1,866	242	605	0	6	27	33	16	69	950	2659
April	966	3,166	117	46	665	2,006	186	618	2	4	20	24	25	108	953	2665
May	879	2,727	92	35	600	1,762	170	478	2	2	29	21	13	92	945	2580
June	1074	2,978	110	42	704	1,759	250	524	4	2	36	59	35	113	1008	2640
July	1018	2,940	132	42	727	2,059	255	666	1	4	15	40	14	117	936	2361
1954 total	6324	19,997	787	282	4395	12,815	1585	4017	15	28	158	220	149	741	—	—

* Figure incomplete.

Courtesy Rinehart Oil Reports

Exploration

OKLAHOMA

★ Deep Rock now has four wildcat operations underway in Oklahoma, with 2 tests being conducted in Logan County and 2 others in Lincoln County. Objective pay formations for the Oklahoma wildcats range in depth from 5500 to 6500 ft.

★ Phillips Petroleum Company has successfully tested a third flowing pay formation of its No. 1 Steve, new Grady County, Oklahoma, multi-zone discovery well, 1½ miles southeast of Bradley. On this test the well flowed 48.1 gravity oil at the rate of 327 bbl per day through a small choke from perforations in the Third Bromide formation between 12,885-973 and 13,002-050 ft. Gas-oil ratio was 3768:1.

The new well previously flowed through small chokes at the rates of 411 bbl of oil per day from perforations in the Oil Creek formation between 13,735-804 ft and 728 bbl of oil per day from Basal McLish perforations between 13,294-325 ft.

The First and Second Bromide formations yielded substantial quantities of oil on drillstem tests Drilling of two or more deep test wells near the discovery well is proceeding, and the company is moving in equipment to start another test a mile northeast.

LOUISIANA

★ Texas Gulf Producing Company has discovered a new gas-distillate field in Beauregard Parish.

On test, the Herpin No. 1 obtained a calculated 24-hour potential flow of 2,110,000 cu ft of gas and an estimated 100 bbl of 56-gravity condensate, through a 14/64-in. choke. Production came from casing perforations between 7275-7280 ft.

KANSAS

★ Deep Rock Oil Corporation has announced that 5 new wildcat operations are under way or scheduled in Stafford and Pratt counties, Kansas, an area in which Deep Rock has been active in exploration and production work previously. Objective pay formation is the Arbuckle lime which is found at a depth of 3500 to 4425 ft in the area.

Drilling is already under way on two of the Kansas wildcats. Locations have been selected for the other three tests and drilling will be conducted on a continuous basis.

★ Location of Guffey No. 1, a test well in Pawnee County, Kansas, has been announced by Cities Service. The well is located C SE NE SW, Sec. 35-22S-15W. A projected total depth of 4100 ft in the Arbuckle dolomite has been set. Well is 10 miles southeast of Larned, Kansas, and 1½ miles east of Dunes field. Natural Gas and Oil Company has an interest in the test.

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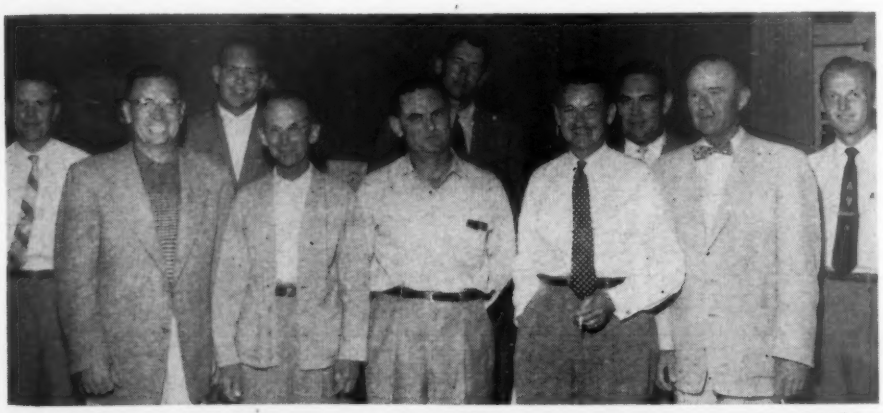
RUNNING TOUR with MEN in the INDUSTRY

Arnold S. Bunte has joined the staff of the Denver National Bank, Denver, Colorado, in the capacity of consulting geological engineer. A graduate of the Colorado School of Mines, Bunte was employed by the Shell Oil Company as exploration geologist from 1926 to 1938. He served as consulting geologist and engineer in Kansas, Oklahoma, Texas, Louisiana, and Arkansas until 1941, at which time he joined the Vickers Petroleum Company. In 1953 Bunte joined the faculty of the Colorado School of Mines as Associate Professor of Geology, a position which he will continue to hold.

F. W. Stewart has been named field representative for the crude oil supply division of Cities Service Oil Company in Oklahoma City, Oklahoma. Stewart had been serving in the same capacity at New Orleans, Louisiana. He joined Cities Service in 1936 and has worked in both the secretary's and treasurer's divisions.

Arthur C. Munyan has been transferred to Sohio Petroleum Company's Billings office as staff geologist. He will oversee all geological staff work in the northwest division. **Jack H. Walters** has been transferred from Sohio's Tyler office in the Gulf Coast division to the Casper district, northwest division where he will be district superintendent of operations. Walters replaces **Clayton W. Nygaard** who was transferred to Sohio's Russell, Kansas office in the Mid-Continent division.

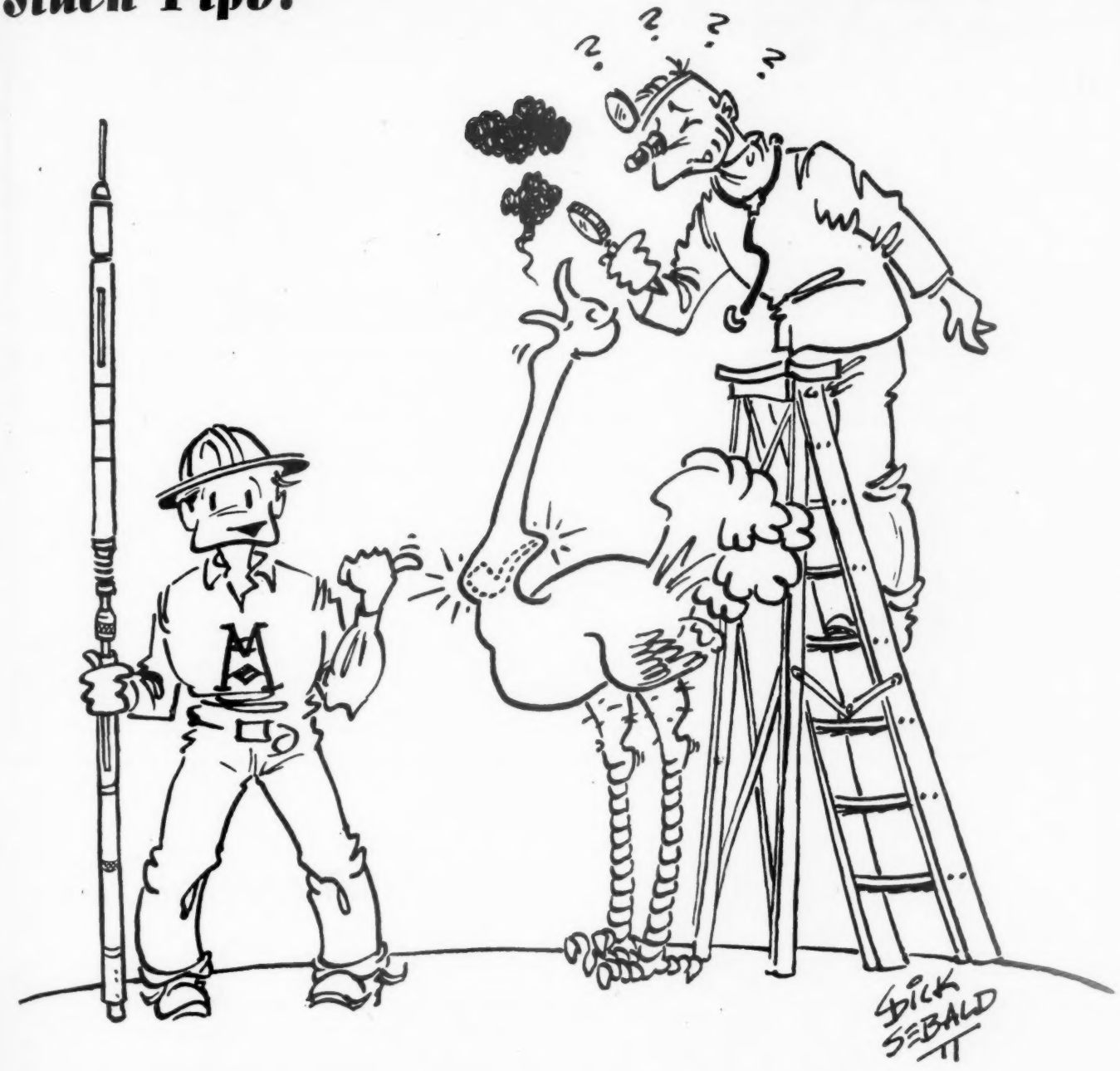


Los Angeles Nomads held its annual Whing Ding at the Riviera Country Club on July 16. Winners of the golf tournament prizes were: Bill Althouse, Baker Oil Tools, high gross, Nomad; Lee Laird, Cardwell Manufacturing Company, low net, Nomad; Frank Hoover, Hoover Drilling Company, longest drive, guest; W. T. Archer, CPA, nearest to pin, guest; Cecil Weaver, Johnston Testers, low net, guest; John Fowler, Pike Drilling Company, tie for high gross, guest; Bill Bettis, Johnston Testers, longest drive, Nomad; Conny Ridgeway, Aramco, tie for high gross, guest; Paul Bowen, S. R. Bowen Company, low gross, Nomad, and Jack Augsburger of Tryad Service Company, low gross, guest.

LA Nomads Whing Ding door prize winners were: Ben Bayliss, Loyd Corporation; Ross Wiley, Eastman Oil Well Survey Company; W. Green, Loffland Brothers; Ernie Fowks, Emsco; W. C. Gramm, Iraq Petroleum Company; John McEwen, Stansbury, Inc.; Lee Laird, Cardwell Manufacturing Company, and Arnold Prosser, and Charles Hansen, Shell.

Sun Oil Company engineers and college instructors who partic pated in a four-week course in advanced reservoir engineering at The College of Mineral Industries of The Pennsylvania State University. Front row: W. C. Sturdivant, O. Lewis Smith, A. Douglas Brown, G. G. Lancaster, B. M. Gottlieb, and R. F. Neilsen (instructor). Second row: James E. Goodson, Earl F. Thomas, E. Dibrell, William Brown, Jr., Kenneth E. Barnett, and Joseph E. Warren (instructor). Third row: W. E. Thompson, George E. Haas, George B. Dowell, Marion D. Noble, L. C. McColloch, C. E. Thomas, and Dave Oakes (instructor). Fourth row: T. G. Calhoun, II, M. Dayton R. J. Ridgway, K. E. Montague, Paul B. Fletcher, Floyd Preston (instructor), and Dr. John C. Calhoun, Jr. (instructor).

Stuck Pipe?



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Indiana Kentucky Geological Society

The Indiana Kentucky Geological Society was founded in 1938, and was then known as The Western Kentucky Geological Society. In 1940, it became the Indiana Kentucky Geological Society and was affiliated with the American Association of Petroleum Geologists.

Object of this society is to, "promote the science of geology," particularly in its association with the oil and natural gas industry of the area; and to promote social and professional association and provide a meeting for the presentation and discussion of subjects of mutual interest.

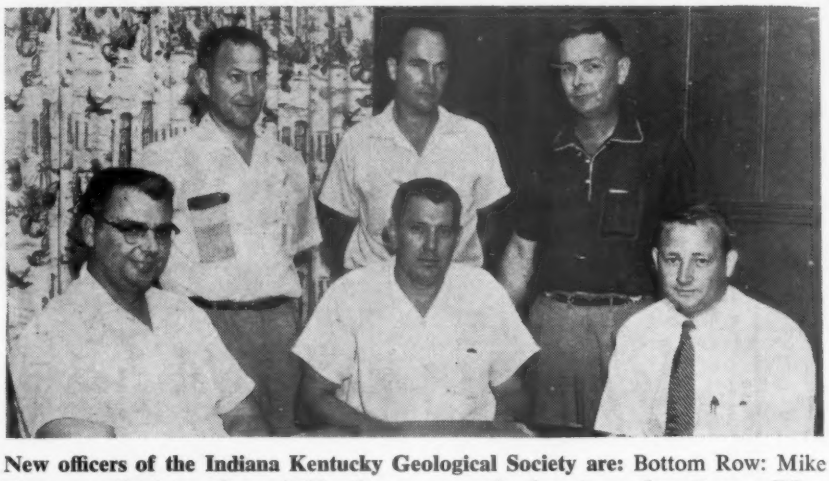
The Indiana Kentucky Geological Society is a non-profit organization, and is completely supported by its own membership. Approximately 32 per cent of the members are employed directly by oil companies, 65 per cent are consulting geologists, and the remaining 12 per cent of membership is made up of personnel of the State geological staffs, the teaching staffs of universities and colleges, as well as members of service companies.

A petroleum geologist is primarily a scientist engaged in exploration for oil, in the development of oil properties, and in the evaluation of oil properties. It is the geologist who finds the oil and who paces the discovery rate of that great industry.

A geologist must have vast knowledge and much experience at his command to be able to envision the sub strata of our own earth; to draw, from scraps of available information, a picture of the various layers of the earth in their relation to one another. The mysteries of formation, the vagaries of nature, and wild imagination are constant battles to he fought, by the geologist.

The "Code of Ethics" of the American Association of Petroleum Geologists reads thus: "The practice of petroleum geology is a profession; it is the duty of those engaged in it to be guided by the highest standards of professional conduct, and to subordinate reward and financial gain thereto."

In this age of dollar economy, it is indeed a rare thing to find a code of professional conduct so dedicated to science as to relegate the dollar to a position of secondary importance.



New officers of the Indiana Kentucky Geological Society are: Bottom Row: Mike Henerson, district engineer, Schlumberger, executive board member; Roscoe Wise, geologist, Sun Oil, secretary and treasurer, and Robert (Cotton) Sublett, geologist, W. C. McBride, president. Top row: William (Bill) Davis, consulting geologist, executive board member; Jim Kendall, consulting geologist, executive board member, and Kenneth G. Boling, consulting geologist and oil producer, vice president.

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Thomas L. Wark, vice president, has been appointed divisional general manager of Tide Water Associated Oil Company's western division. **Charles R. Brown,** vice president, has been appointed assistant divisional general manager. Wark has been with Tide Water for 34 years, beginning as resident geologist at Ventura, California. Brown has been with the company since 1917. He has been a vice president since 1948.

E. L. Gorham, Jr., has been named manager of joint operations of The Texas Company's foreign producing department. He was formerly assistant manager, Venezuelan division, of the Texas Petroleum Company in Caracas. Gorham joined Texaco in 1935, after completing graduate work in petroleum engineering at Louisiana State University.

Charles T. Crewell has been named area land agent for Shell Oil Company's Calgary area. He will be replaced as San Joaquin division land manager by **Durland E. Clark, Jr.**

Crewell has more than 25 years of service with Shell. He joined the company as a service station salesman. Clark is an engineering graduate of Virginia Military Institute and a law graduate of the University of Virginia. He joined Shell's land department in Los Angeles in 1948 as a title examiner.

William H. Thomas has been appointed as chief scout for Shell Oil Company, succeeding **E. L. McDowd** who has retired. Thomas, a graduate of Colorado College, has more than 21 years of service with Shell. He began his career in the company's exploration department as a laboratory assistant.

Roger D. Sears has joined the Lion Oil Company staff of the Bismarck, North Dakota, district office as junior geologist. He is a graduate of the Colorado School of Mines. **Bernard V. Berardini** has been employed as junior landman in the Casper, Wyoming, district office. He is a graduate of the University of Denver. **Joseph A. Larkin** has been placed in the Colorado production district office at Fort Morgan as senior clerk. He was formerly employed with Carter Foundation Production Company of Kermit, Texas.

Marvin H. Morris has been appointed division manager for Texas Gas Exploration Corporation's Lafayette, Louisiana, office. He formerly was associated with Arkansas Fuel Oil Corporation and The Texas Company. Morris is a graduate of Southwestern Louisiana Institute.

Charles C. (Cub) Frye has been appointed chief engineer of Hudson's Bay Oil and Gas Company, Ltd., Continental Oil Company's Canadian affiliate, Frve, a graduate of Oklahoma A and M College, was formerly with General Electric Company. He joined Conoco in 1933 as a petroleum engineer.

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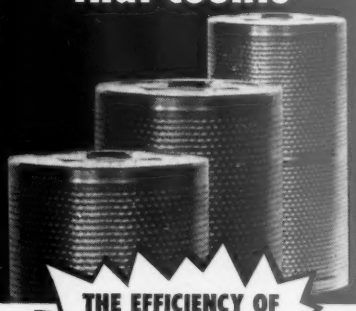

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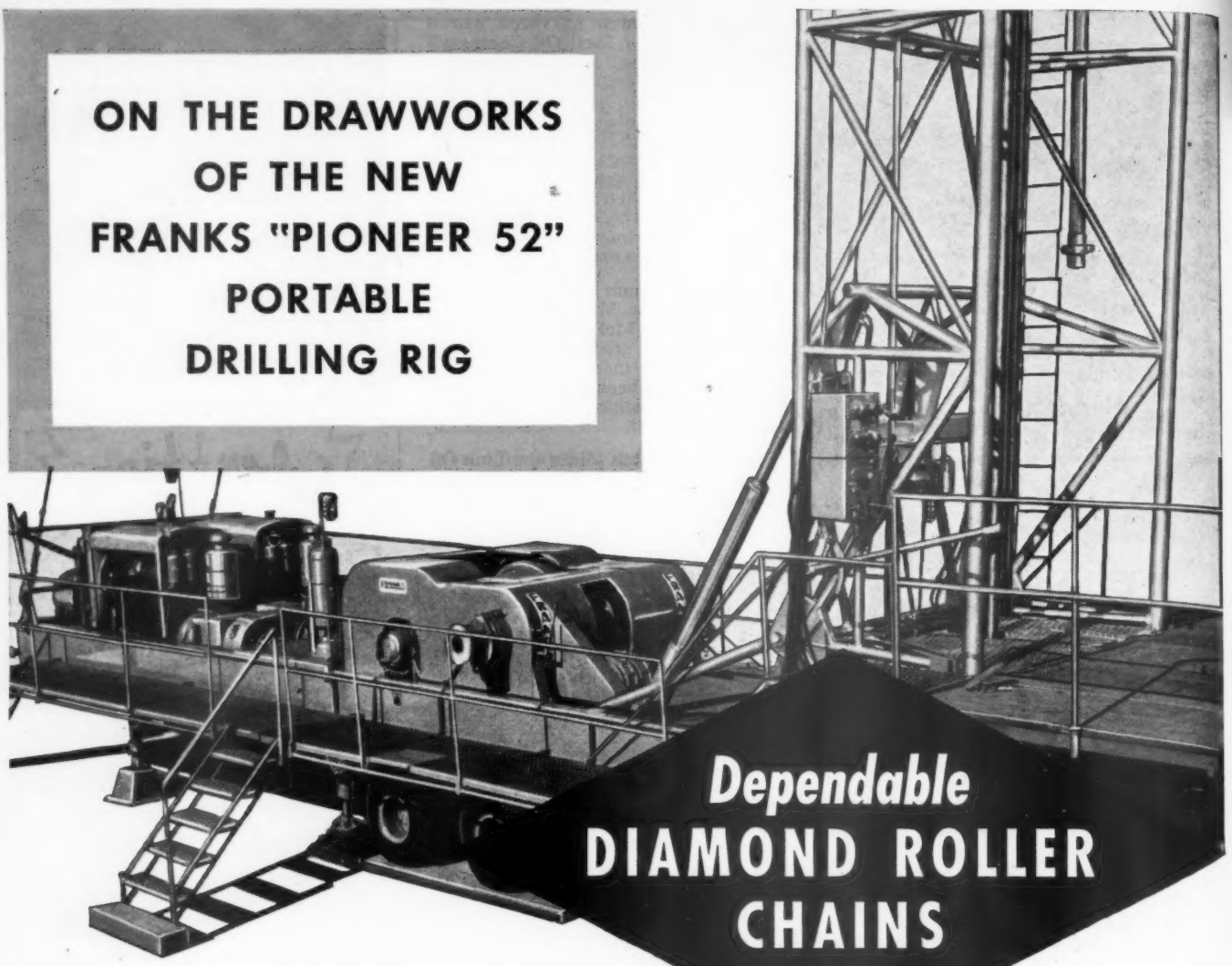

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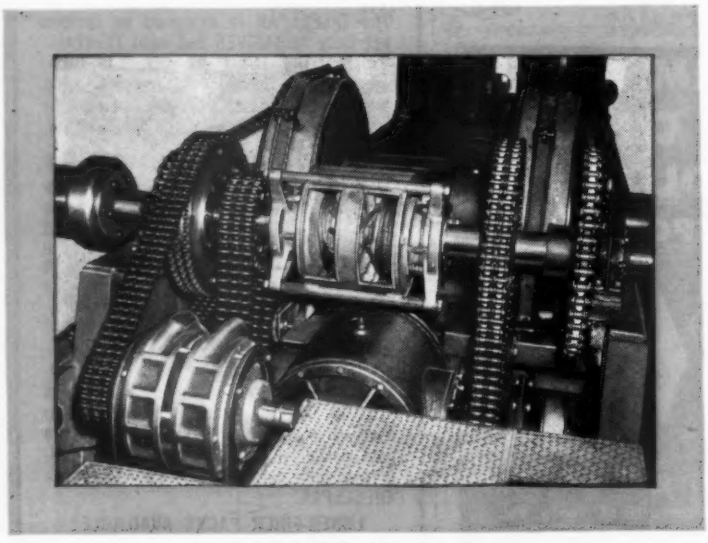

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Today, Davison is producing Atlantic Platinum Reforming Catalyst on a commercial scale and shipments are being made at an increasing rate to licensees of the Atlantic Catforming Process. Davison has an outstanding record of this type of development in many fields of commercial catalyst production. If you have a catalyst problem, see your Davison Field Service Engineer or write.

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PRODUCERS OF: CATALYSTS, INORGANIC ACIDS, SUPERPHOSPHATES, TRIPLE SUPERPHOSPHATE, PHOSPHATE ROCK, SILICA GELS AND SILICOFLUORIDES. SOLE PRODUCERS OF DAVCO GRANULATED FERTILIZERS

Furmatic — Hit or Miss?

Has a new process been developed for making carbon black from either gas or a gas-oil mixture, of up to 50 per cent liquid oil that will render obsolescent older channel, furnace, or "thermal" processes, or is it just another process? That is one of the "$64" questions being asked by carbon blackers about the Lynn Furmatic Process, now in pilot stage. Contracts for 10 plants have been reported and inventor Rice Lynn has licensed Consolidated Carbon Corporation of Illinois exclusively to build these and any other plants. Lynn gets $30,000 per plant for "construction supervision," and 1¢ per lb of black royalty. Claimed investment is 30-50 per cent lower than other processes of same amount of recovery. Oil or gas-oil mixture is sent to novel spherical furnace, air admitted, filtered, and the charge is burned. The carbon black is cooled by countercurrent air, agglomerated, and bagged. Inventor says yields should run 40-50 per cent greater than current processes. No commercial unit is yet operating, nor claims yet substantiated on large scale.

★ ★ ★

Industry Climbing a Hill

The chemical and some other industries are climbing the hill, back toward more business, says Federal Reserve Board. Upturn is not much, expect business curve to stay low during summer, start upward in earnest in early autumn. Only calamity howlers and socialistic minds will be disappointed at this clear evidence of the upward trend.

★ ★ ★

Acetylene—Building Block

Production of acetylene in "pipe line" quantities at Cyanamid's Fortier, Louisiana, plant, and Goodrich's Calvert City, Kentucky, unit bids fair to evolutionize some organic (petrochemical) sources for numerous materials. Because of the acetylene synthesis of acrylonitrile production of that very important ingredient of oil-resistant rubber, plastics, etc., is expected to jump to nearly 200,000,000 lb in 1955, more than three times our 1953 production. In the wake of cheap and available acetylene follow all sorts of materials; tertiary acetylenic alcohols, acrylate polymers, glycols, and oodles of other items. One of the "jawbreakers" is cyclooctatetraene, made by cyclopolymerization of acetylene. It rearranges to make aromatics, is oxidized to terephthalic acid, base intermediate for Dacron-type fibers, makes plasticizer ingredients with maleic anhydride, seven-carbon rings analogous to benzene ring. Acetylene is polymerized and combined to form polyvinylpyrollidone, used largely as a blood volume expander, also for milady's "set" for her hair-do, a bactericide in combination with iodine, and is said to have an untold number of far-reaching uses.

★ ★ ★

A Tanker of "Dry Ice"

Brea Chemicals, California, makes more dry ice than anybody in the West. At least one tanker can be said to have a "cold deck;" Brea shipped recently a shipload of solid carbon dioxide. Brea has 150 tons per day capacity, in two plants.

★ ★ ★

GAF May Be Set "Free"

Maybe the U. S. will give back some of the "marbles" of chemical firms of foreign ownership that it picked up during World War II, if the Dirksen-St. George bill passes Congress. Bill was snowed under earlier, but Big Stick Dulles has put in a word for it, so it may go through. Bill would give back properties or the money value of them. One big firm is General Aniline and Film Corporation, $140,000,000 worth, that might revert to the Swiss holding company Interhandel that has been suing for the return or equivalent for some time.

★ ★ ★

Nitrogen to Cure Cancer?

One type of the many kinds of cancer has been cured 100 per cent in rats by triethylene melamine (TEM) at the Sloan-Kettering Cancer Research Institute. Other chemicals showing more or less promise are triethylene phosphoramide, aminopterin, and triethylene thiophosphoramide, products that have shown cures of from 71 to 83 per cent of various forms of cancer. It is recalled that the late Dr. J. R. Bailey, pioneer researcher in petroleum nitrogen compounds felt that these products just might be useful in making chemicals effective in the fight against cancer.

Mme. Curie a Communist

It comes as no surprise to most of us, after the public print airing of facts and correspondence on the matter, that the world-famous French woman scientist, generally referred to as Madame Curie, is a communist in her political beliefs, as is her husband, M. Joliot. Rather naively, we think, she states in a recently published letter in C&EN, ACS news journal, that "I do not let political matters enter into scientific work." According to the principles of activity of the communists it is not possible for a person to follow that political doctrine without its permeating every move, thought, and activity. The communist is devoted, supposedly selflessly, to the forcible overthrow of all non-communistic governments and activities, and consecrated to the use of every possible means, however foul and unfair, brutal and murderous, to accomplish this end. It is not possible to be half-communist, half-free; the "pink"" fellow-traveler is as Red as the Moscow leaders.

Mme. Curie is therefore impaled on her own halberd. In her position as a leading scientist she would be in a perfect position to learn, steal, and transmit to Moscow all atomic secrets in this country or Britain; to aid immeasurably in the overthrow of these two leading free governments. If she believes the communistic dogma that is exactly what she will do, may already be doing. Communist distortion of the history of science, their claims of having discovered practically everything in scientific developments, means that no true scientist can be a communist, the two positions are mutually antagonistic, mutually exclusive, one cannot exist with or within the other.

P. S.: Her husband supported the Soviet "big lie" about the U. S. using biological warfare agents in Korea.

★ ★ ★

For Research—$60,000

From petroleum and petrochemical sources the University of Texas has already received $60,000 in donations to support 19 research projects in geology, chemistry, petroleum engineering and petrochemical development. Eight of these are on petrochemical problems.

Another $25,750 in grants is to be awarded later for projects largely in the chemical engineering field.

XUM

ETHYL RESEARCH BUILDS A "WHIRLING PIN CUSHION"

to probe the secrets of combustion deposits

A special whirling disk developed by Ethyl research people may help technologists come up with the answer to one of the "hottest" problems facing the petroleum and automotive industries.

The problem: Exactly what can be done about the deposits that build up in the combustion chamber of a modern gasoline engine?

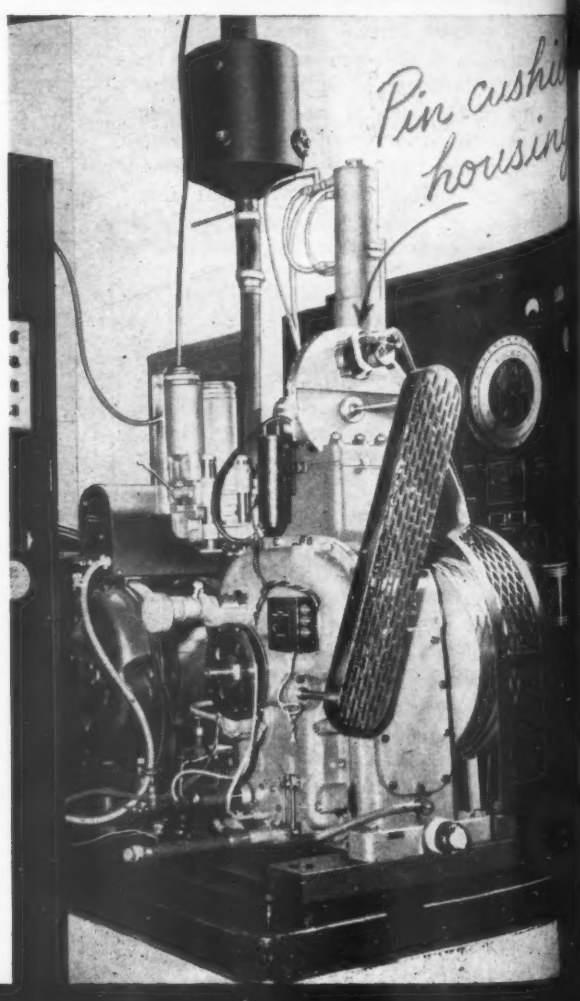
Only when researchers can understand what they are and how they form through the interaction of fuels, oils, additives and the metals of the engine, will it be possible to render these deposits harmless.

Ethyl research people have been at work on the problem for years and in many different ways. Recently, they made another step forward when they developed an amazingly simple test instrument they affectionately call the "whirling pin cushion."

By spinning the pin cushion in a special test rig, researchers are now able, for the first time, to trace the step-by-step formation of combustion products—at all phases of the cycle.

This is another milestone in basic research on combustion-chamber deposits.

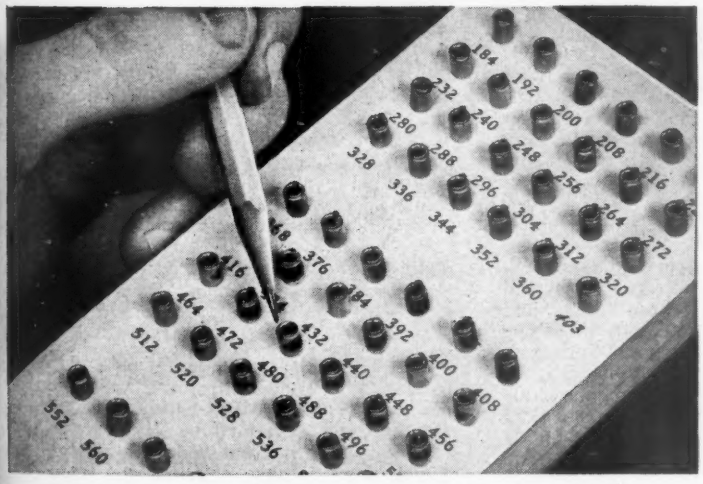
New test instruments at Ethyl Laboratories like the "whirling pin cushion" are helping us piece together the fundamental knowledge which will eventually open the door to engines and fuels of far greater efficiency than are possible today.



Special test engine synchronizes the "whirling pin cushion" with the engine cycle so that each pin picks up deposits from exactly the same portion of the cycle each time.

XUM

Sampling "pins" on Ethyl's "whirling pin cushion" move past a specially constructed opening in the cylinder head of a test engine and pick up combustion deposits—as they are being formed.



Each pin on the disk accumulates deposits formed.

Ethyl laboratories "fingerprint" the deposit on each sampling "pin" by X-ray diffraction.

ETHYL CORPORATION
Research Laboratories

1600 West Eight Mile Road, Ferndale 20, Michigan
2600 Cajon Road, San Bernardino, California

XUM

REFINERY PLANTS SCHEDULED FOR COMPLETION

E. I. duPont & De Nemours and Company. Option on a plant site for a projected tetraethyllead and Freon manufacturing plant has been obtained by duPont at an undisclosed location, announcement states. Plant will include the latest developments in manufacturing these products, the familiar lead for motor fuels, and Freon a refrigerant used in mechanical refrigerators. Design is being pushed on the plant, it is reported, though nothing is said about when and where, or how much.

★ ★ ★

Continental Oil Company. Continental has just finished spending $16,000,000 for, via Stone and Webster Engineering, an expansion program including a unit for the recovery of aromatics, benzene, toluene, and xylenes from refinery fractions rich in these products. Benzene will be employed to make a synthetic detergent, while toluene and xylenes may go into aviation fuels, synthetic fibers (paraxylene), in the case of toluene into high explosives. The program includes catalytic cracking, reforming and polymerization, along with other items.

★ ★ ★

Socony-Vacuum Oil Company. Thirteen catalytic reforming units will be built at Socony's various refineries in this country, George S. Dunham, manufacturing executive for Socony says. Two processes will be used — Sovaform and Thermofor Catalytic Reforming (TCR), both Socony developments. Total capacity will be 130,000 bbl per day, in 11 refineries. This is all included in the $165,000,000 to be spent by the company by the end of 1956.

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Foreign Plants. Six platformers are under construction at AIOC refineries in the United Kingdom (two), Aden, France, Germany, and Australia. Five have annual capacities of 250,000-tons, but Aden's platformer throughput will be 500,000-tons annually.

★ ★ ★

Salt Lake Chemical Company. Construction is to begin right away on an $8,000,000 anhydrous ammonia plant near Salt Lake City. Plant is said to be operating by the end of 1955. Plant will make 120 tons of anhydrous ammonia per day, plus 30 tons of dry ice. Latter is the result of solidifying the carbon dioxide formed in the partial combustion of natural gas to obtain hydrogen for the synthesis. J. B. Allinson is president of the company, and says they will supply local fertilizer manufacturers with ammonia and raw materials for their businesses.

★ ★ ★

Rock Island Refining Corporation. A 2400 bbl per day platforming unit has gone on stream at the Rock Island Refining Corporation near Indianapolis. It operates on the heavy fraction of straight-run naphthas from mixed crudes, and will produce 95-octane number reformed gasoline, officials say. Unit is controlled electronically throughout. It was designed by Universal Oil Products Company, the licensors, and was built by the refinery staff in approximately 21 months.

Allied Chemical and Dye. Allied Chemical and Dye's Nitrogen division will soon double the capacity of its Omaha, Nebraska plant, now producing 61,000 tons per year of ammonia and urea. Building the additional capacity will begin as soon as assurance is had of the additional supply of natural gas that will be required. This additional capacity is added to that of the Division's two other ammonia plants at South Point, Ohio and Hopewell, Virginia. Northern Natural Gas Company which now supplies gas to the Omaha plant, has applied to Federal Power Commission to increase the supply.

★ ★ ★

Commonwealth Oil Refining Company. Financing of a $24,500,000 refinery at Ponce, Puerto Rico has been announced by Commonwealth. It will have nearly 22,000 bbl of crude capacity per day, will be built by The Lummus Company and be completed by the end of 1955. Financing will be handled by stock sales, debentures, and borrowing cash from U. S. and Puerto Rican banks.

★ ★ ★

Oronite Chemical and British Distillers. A plant for the manufacture of all types of lubricating oil addition agents is under construction in Hull, England. Plant is joint venture of Oronite Chemical Company, Standard Oil of California petrochemical sales subsidiary, and British Distillers Company. Early 1955 is the expected date for starting operations, report says. This development portends an onslaught on the European market for all these types of products, in which American companies, with a few exceptions, and Oronite in particular, have not had a large share up to now.

★ ★ ★

Gulf Oil Corporation. Construction has begun on a gas purification unit at Gulf Oil's Port Arthur, Texas refinery. Unit is to be an auxiliary to Gulf's expanding ethylene producing unit. The Girbotol process will be used and will remove hydrogen sulfide and carbon dioxide from gas destined as charge stock for the ethylene unit. Sulfur will be recovered from the H_2S, the carbon dioxide will be vented to the air during regeneration of the diethylnolamine extract solvent. Unit is expected to be on stream by the end of the year.

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Eastern States Petroleum Company. License for a Unifier unit has been signed between Eastern of Houston, Texas, and Union Oil Company of California, along with Universal Oil Products Company; developers and licensors of the process. Unit will desulfurize and upgrade 3000 bbl per day of cracked gas oil. It will be built by the company at Houston and is expected to be on stream sometime in September.

★ ★ ★

Atlantic Refining Company. A new unit to remove hydrogen sulfide from a Catformer recycle hydrogen stream is on stream for Atlantic at Atreco, Texas coastal area. Girdler Corporation did the design and engineering.

Shale Oil Power Plant. An American firm of consultants, Ebasco Services of New York City, has been retained by Canadian interests to study and report on the feasibility of developing a new power project that is to be based on oil shale deposits in New Brunswick, eastern Canada. The provincial government is interested in looking into the matter closely. Nashwaak Corporation of Canada, Ltd., has a "finger in the pie," in fact it is understood made the first proposal. Proposed project would cost $7,500,000 and would generate power with shale oil as fuel. Curious quirk in the proposal is that alumina, reportedly high in the spent shale, may be a separate chemical project to come out of the investigation.

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Sunray. A 5000 bbl per day platformer went on stream August 14, at Sunray Oil's refinery at Sunray, Oklahoma. Platformer was completed by Refinery Engineering Company of Tulsa, Oklahoma.

★ ★ ★

Imperial. A new lubricating oil plant of 1700 bbl per day capacity is being built at Edmonton, Alberta. Plant will cost $14,000,000 and will be completed late in 1955.

★ ★ ★

Union Oil Company. Petroleum coke and sulfur will be the major products from the 20,000 bbl per day coking plant being built by Union near Santa Maria, California. Plant will have twin cokers of 10,000 bbl per day each. Sulfur will be recovered from gases and vapors and 43 tons per day is the desiened yield. Crude from the Santa Maria field will be processed, brought to the plant via pipeline.

★ ★ ★

Brea Chemicals, Inc. Ammonium phosphate for the farms of the West Coast will be manufactured by Brea, says Homer Reed, Brea president. This unit which has just begun construction will operate in conjunction with the synthetic ammonia plant nearby, producing ammonia from air and hydrocarbons from which the hydrogen is obtained. Phosphate will be produced for the market in solution form, a product that appears to be popular on the West Coast. Union Oil expects to have two similar plants operating at Fresno and at Brawley, California, early in 1955. Macco Corporation of the Los Angeles area is building the Brea plant. It is to be completed sometime in September.

★ ★ ★

The Texas Company. The biggest platformer unit ever built, for 20,000 bbl per day, went on stream early in August at company's Port Arthur, Texas, refinery. This unit is combined with a Unifiining plant which prepares the feed stock for the reformer. Combination will operate on straightrun, low grade naphthas from Texas and Louisiana crudes. It can be used to produce motor fuel blending stock, or to refine aviation base stock, as may be wanted. A similar unit is now being built in the same refinery, to be completed sometime in 1955. Procon, Inc., built this unit.

Shell Oil Company photo

Night view of Shell Chemical's Houston, Texas petrochemical plant, one of the largest in the world, making a wide variety of products.

P 793.1

NEW PHASE DEVELOPS IN PETROCHEMICALS

Overbuilding of capacity may crowd the market temporarily; some price declines result from technical advances, may be new normal levels

B. T. BROOKS[1] and E. B. BRIEN[2]

THE recent price declines for many of the major items in the field of petrochemicals, although serious for some companies, is no indication of a general business slump or even that the manufacture of chemicals from hydrocarbons in general is an exploded bubble.

No generalization is applicable to all petrochemicals except perhaps that the manufacture of chemicals from hydrocarbons has been greatly ballyhooed in the general news and very often in the technical journals.

Many recent interviews with executives of chemical companies have shown substantially complete agreement that in this segment of the chemical industry a saturation point in production and sales has been reached for many important items and is being approached or threatened for others. This does not mean that the consumption of these chemicals has become static or further growth stopped.

In some cases the recent price declines have been due to technological improvements in manufacture and many striking examples of this, over the years, might be cited. For example, Carbide and Carbon Chemicals Company introduced ethylene oxide in 1929 at $2 per pound in 100 gal drums, in 1939 sold it for 29 cents in tank car lots and the current price is about half of the 1939 level.

A similar price history holds true for propylene oxide, originally introduced at 75 cents per pound and ethylene glycol which originally sold as an anti-freeze for $5 per gallon. Ethylene oxide was originally made exclusively from ethylene chlorohydrin but now produces it by direct catalytic oxidation of ethylene in 4 large plants with 2 more under construction.

Some of the petrochemicals that have recently declined markedly in price are among those that can be made without preliminary research, the payment of patent royalties or fear of infringement suits, and for which the necessary know-how and plant design has become generally known. Newcomers in the field of petrochemicals have in many cases undertaken the manufacture of products such as ethylene glycol, ethylene oxide, ethanolamines, ethyl alcohol, ethyl chloride, ammonia, methanol, and other products enjoying large established markets pioneered and developed by others.

In many cases, the newcomers can only expect close competition and narrow profit margins, the older companies having the advantage of lower cost of their plants, early cost write-off, established good will and in many cases having enjoyed the higher profits possible under patent protection during the early years. The exceptions are those whose new plants embody technical advantages. An executive of one such company once stated to us that he never favored going into the manufacture of any chemical product without initial patent protection to serve them while they were building up know-how.

The price changes for some of the more important petrochemicals from January, 1951 to August 2, 1954 are in Table 1.

Most of the price declines noted in Table 1 have taken place during the past eight months. The changes noted take no account of sales below listed prices. There have been special well known reasons for the substantial declines in the prices of ethanol and glycerine, which make them special cases. With the exception of these two items, the prices of most others were stable up to July, 1953. The advent of the new process for phenol and acetone, by oxidation of cumene, is not

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EXCLUSIVE

XUM

Lion Oil Company photo

Aerial view of Lion Oil's Barton chemical plant near New Orleans, one of the newest ammonia, nitric acid, etc., units in the industry.

reflected as yet in the prices of these two chemicals.

Although these declining prices do not spell calamity, at least for most of the older established companies that have built up a highly integrated and mutually beneficial series of manufacturing processes through research, they do spell caution or "stop, look, and listen."

TABLE 1. Listed prices for some petrochemicals.
(tank car or tonnage lots)

	Jan., 1951	Aug. 2, 1954	Change, percent
Ethanol, C. D., (gal)	89.5	41.5	—53.6
Glycerine, dynamite, (lb)	53.5	30.0	—43.9
Propylene glycol, (lb)	18.5	11.5	—37.8
Isobutyl alcohol, (lb)	19.5	12.0	—37.1
Ethylene glycol, (lb)	17.0	11.5	—32.3*
Ether, synth, techn., (lb)	14.0	10.0	—28.5
Diethylene glycol, (lb)	18.5	13.25	—28.3*
Butyl acetate, synth, n., (lb)	17.5	13.0	—25.6
Dibutyl phthalate, (lb)	39.0	30.0	—23.1
Ethylene oxide, (lb)	19.25	13.5	—22.1*
Acrylonitrile, (lb)	39.0	31.0	—20.5
Isopropyl alcohol, 91 percent, (gal)	42.0	35.0	—16.6
Vinyl acetate, (lb)	18.0	15.0	—16.6
Morpholine, (lb)	59.0	52.75	—10.6
Formaldehyde, methanol, free, (lb)	3.95	3.45	—10.0
Phenol, synth., (lb)	17.25	16.0	— 7.2
Acetone, (lb)	8.5	8.0	— 5.8
M. E. K., (lb)	11.0	11.0	0.0
Dichloroethyl ether, (lb)	13.0	13.0	0.0
Ethylene dichloride, (lb)	9.0	9.0	0.0
Acetic anhydride, (lb)	13.5	14.0	— 3.7

*Price increased ½ cent lb on Aug. 3, 1954.

Simultaneously with the declining prices noted above, one of the basic costs has greatly increased; i.e., the price of natural gas to industrial consumers in the Texas and Gulf Coast area. In the last six years, the cost of gas at the well-head, to the large gas distributing companies, has increased two to three times. The relatively low cost of natural gas, for use as a chemical raw material as well as for fuel and power, has been one of the major factors in the rapid increase of petrochemicals in the Southwest. As recently noted in these pages, this rising price trend, for gas, may be expected to continue.

Although the increasing cost of gas affects all industrial users, it is more serious for some than others and may affect the petrochemical picture markedly in some cases. One of the important items in the picture in very recent years has been the production of synthetic ammonia based on natural gas. As noted recently in The Petroleum Engineer, however, by-product hydrogen is now available at many new catalytic reforming plants and from plants making ethylene from ethane. Two large new ammonia plants use by-product hydrogen. Also, the average cost of gas to industrial consumers, under new contracts, is now such that the cost of making acetylene from natural gas is about equal to the cost of acetylene from calcium carbide. Air Reduction's new carbide plant at Calvert City, Kentucky, has recently been doubled in capacity. Several recent articles on making petroleum coke indicate plans for using it to make calcium carbide.

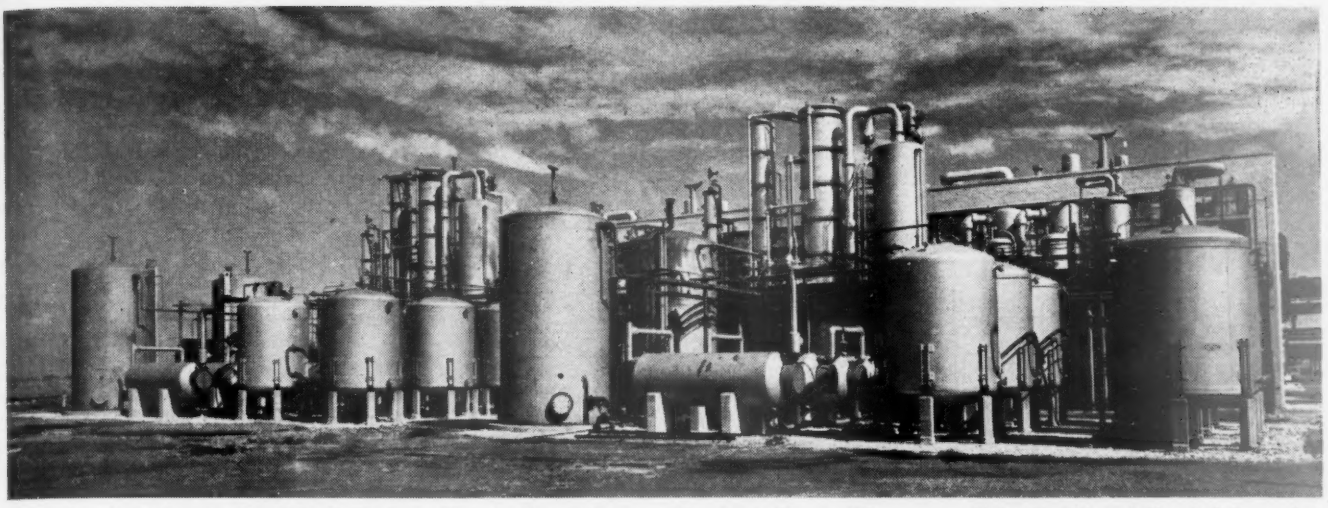
The rapidity of this change in natural gas costs to large industrial consumers in the Southwest is well illustrated by the recent announcement (July 13) that the Mexican Government oil and gas monopoly, Pemex, would contract to sell 100 to 200,000,000 ft of dry gas per day to the Texas Eastern Transmission Corporation at a starting price of 14½ cents per 1000. As recently as 1948 a Monterey group contracted for up to 60,000,000 ft of gas per day from the La Gloria field in Texas at 4½ cents.

The uses of many of the petrochemicals are so diverse that a reasonably correct analysis of recent past history is very difficult, quite aside from forecasting the future. As noted above, price declines in some cases are due to technological improvements and it is not difficult to see examples of this in the current trend.

Thus, acrylonitrile, formerly made exclusively from ethylene oxide and hydrocanic acid, followed by dehydration, is now also being made from acetylene and HCN, and the latter is now much more cheaply made from ammonia, methane, and air by a catalytic process. The 1953 production of 57,000,000 lb of acrylonitrile is expected to be 190,000,000 lb in 1955. The cost of acrylate monomers has been lowered by Kohm and Haas' continuous catalytic method using acetylene, carbon monoxide, and an alcohol, now in operation at Houston. An instance of lower cost due primarily to larger scale manufacture is polyethylene, the production of which is still mounting.

In the examples just noted, the cost-lowering means has been research. Many other similar cases might be given; polyethylene also was a product of research and the new producers have been licensed under the patents.

In our recent interviews with chemical company executives, considerable differences of opinion were expressed as to the relative importance of chemical research, sales, and process engi-



Petrochemical pioneer Carbide & Carbon Chemical's ethylene oxide plant, Texas City. *Union Carbide and Chemical Corp. photo*

neering. It is evident that the relative importance of these factors may vary.

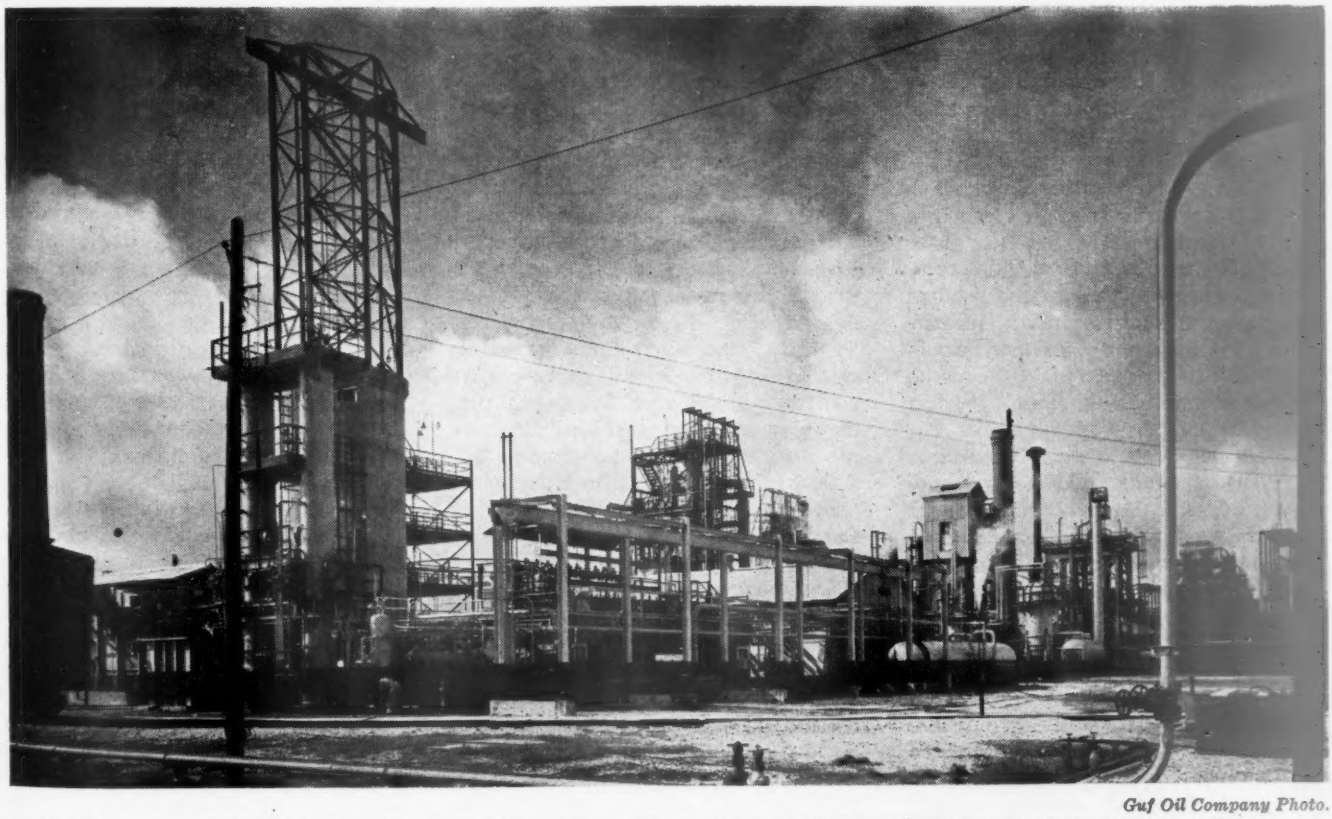
As already noted, it is possible for a new company to manufacture certain chemicals without preliminary research. For example, several good engineering companies can design and construct a complete ethylene plant, an ammonia plant or one for the manufacture of methanol, urea, or ethylene chlorohydrin and glycol. In some cases, a company may acquire a certain amount of the necessary know-how with the patent license, as for example for polyethylene.

Chemical manufacture without research is possible and has been tried before. As regards the value of research, however, we like the opinion expressed by an executive with many years' experience in the petrochemical field, Leo V. Steck, vice president in charge of sales of the Shell Chemical Company.

"R. L. Murray in an address last December, pointed out that the chemical and allied products industry spent $275,000,000 for research, or about 20 per cent of the total research bill for all U. S. industry. As chemical production is only about 6 per cent of all industry, it is easy to determine that the chemical people spent several times as much for research per unit of output as the average industrialist."

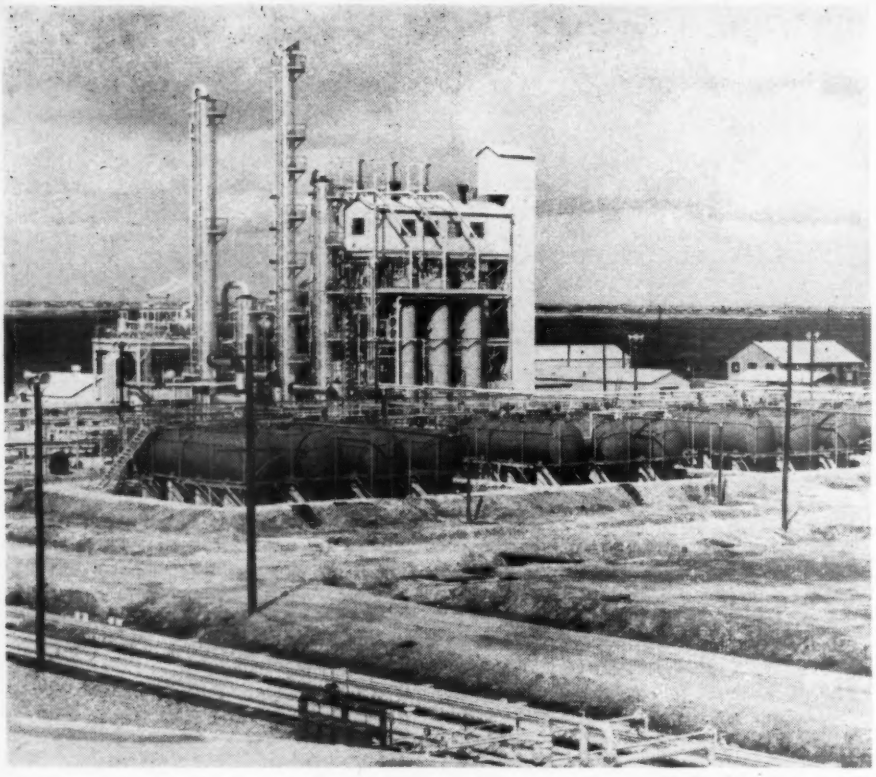
"This is indeed a significant figure leading to the conclusion that a major factor in the good growth rate of the chemical business has been the money plowed back in the form of research. It is highly probable that if one were to analyze the profits earned over the years by various chemical companies, it would be found that those showing the best returns today are just those organizations which have invested most freely in research."

"It is, I believe, axiomatic that the chemical company that has no stake in research will eventually wither and die. Stagnation is the best it can hope



Gulf Oil Company Photo.

Gulf Oil's new iso-octyl alcohol unit at the Port Arthur, Texas refinery, from which the product is shipped via railroad tank car.



Kopper Company photo

Koppers Co.'s Williams, Texas ethylbenzene plant, intermediate for making styrene used in plastics and synthetic rubber; here ethylene gas and benzene are combined chemically.

for, and while such a company may sell the output of its plant and even provide a good return on investment for a limited time, it has no staying power. More progressive companies with well planned research programs will find ways to make the same product cheaper, or better products at the same price." (From address before Commercial Chemical Development Association, New York, March 18, 1954.)

We may add the further comment on Steck's remarks that in chemical plants approximately half to three quarters of the research budget is commonly devoted to process and product improvement, and research in furtherance of sales. One plant manager of many years' experience has said, "There is no such thing as a perfect chemical plant."

Even with such a ratio of research expenditures some good research laboratories turn out new things faster than their companies can put them into commercial production. This does not mean, however, that research can be counted on to get results in a hurry. Two very successful chemical manufacturers have reported that in their experience the time from the start of a research to successful commercial production averaged about seven years. Research is no quick cure for a sick company. Research requires patient money, or as stated some years ago by John E. Teeple, "educated money."

An executive of one of the new petrochemical companies recently stated that his company needed no research and no salesmen — that their several products would be sold to three or four customers on five-year, sliding scale contracts. An officer of one of the largest companies producing synthetic ammonia in the mid-west has emphasized the importance of service in the sale of this one staple commodity.

As regards the importance of sales, we call again on Steck, who states that technical service and product application are two indispensable adjuncts to marketing. Both require research. "Twenty years ago it was relatively easy to get work done by a prospective customer in his own laboratory, but the same customer must now be shown how to use the product.

A great deal of data on a variety of properties is in fact indispensable in starting and maintaining a satisfactory rate of penetration into a new market." Carbide has done such work for more than 100 products. All of Carbide's synthetic organic chemicals, up to about 1930, were industrially new. Selling ethylene glycol in large quantities at a much higher price than any of the competing anti-freeze compounds, denatured ethyl alcohol, methanol, isopropyl alcohol, and gylcerine, was a feat of salesmanship.

In view of the average time required for research and development of new products, and the time and money necessary for sales efforts in the early industrial stage, one wonders how our forefathers ever arrived at 17 years assumed protection as adequate reward for the complete disclosure of a new process or invention.

The Shell Chemical Company's process for synthetic glycerine and the related products allyl alcohol, allyl chloride, and epichlorohydrin, were worked out sufficiently to start industrial production by 1937 but for various reasons incident to World War II, industrial manufacture was not started until 1948. Patent protection for 17 years may have been reasonably adequate 150 to 100 years ago before the days of modern costly, time-consuming research, but it is hardly adequate now for the benefit that the framers of the original patent law evidently intended.

It is fairly evident, however, that the companies which have been outstandingly successful have maintained their position, not by reliance upon patents which initially may have been very important, but by further research. There are many conspicuous examples of this fact outside the chemical industry also. Thus we come back to research, which Steck has likened to the center on the team.

In this discussion we started out to analyze what appeared to be some of the factors in recent price declines for many organic chemicals, which considered by themselves might seem somewhat alarming. We have omitted and made no attempt to evaluate the relative importance of process engineering and good management in the petrochemical industry. Both are obviously essential and it seems idle to labor the point.

In conclusion, we may venture the opinion that the petrochemical industry has benefitted by rare good luck. As recently noted in these pages, the great increase in the demand for the products of this industry has been due to the great developments in other consuming industries, synthetic textiles, plastics, detergents, oil and motor fuel additives, lacquers and other coatings, insecticides, etc. In general, these industries are still growing. If too much ballyhoo has caused too rapid expansion in the productive capacity in some lines this promises to be corrected by further normal growth. In so far as price declines have been due to sharpened competition or even distress selling, this situation may be corrected, but where the declines are the result of improved technology the new levels may be new normal levels. If some companies are hurt in the interim it is not likely to be the wiser, older ones. * *

XUM

Methods for Gas Dehydration for 1954

No one type of equipment offers the best solution to all dehydration problems; close analysis of process needs is necessary

JOHN M. CAMPBELL*

THE subject of gas dehydration is one that has received widespread attention in the past several years. Most aspects have been discussed in varying detail as may be noted by reference to the bibliography. The general design and economic factors have also been recently summarized.[1]

In the last several years, however, the use of gas dehydration has expanded somewhat, and new procedures and equipment have appeared. It therefore appears apropos to discuss these new applications and techniques.

The following represent the most significant developments:

1. Expanded use of glycol dehydrators for gathering systems.
2. More widespread use of refrigeration, both expansion and mechanical, for dehydration.
3. Improved dry desiccant materials and techniques.
4. Development of glycol dehydrators to give greater dew point depressions.

Gathering Systems

As more gas and gas condensate production is developed it is quite natural that gas gathering problems become more critical. The choice of system to prevent hydrate formation must depend on operational factors as well as economics. Continued exploration has naturally developed production in less accessible locations, where continuity of operation and ease of maintenance are of prime importance.

Inasmuch as the ground temperatures surrounding buried pipe are usually between 40-55 F some method of hydrate prevention is normally advisable when the gas pressure exceeds 200 psig. This is normally accomplished by:

1. **Gas heaters**
2. **Injection of hydrate inhibitors**
3. **Dehydration**

The advantages and disadvantages of these systems are summarized in Table 1.

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TABLE 1. Comparison of gathering system hydrate prevention systems.

System	Advantages	Disadvantages
Gas fired indirect heaters.....	No moving mechanical parts. Easy to maintain. Relatively inexpensive.	Not a positive method of preventing hydrates. High fuel consumption for protection offered. High heat loss to ground which limits amount of protection offered.
Injection of methanol.....	Simple system involving little or no gas consumption. Relatively little equipment involved. Low initial first cost.	Involves mechanical equipment and the necessity of hauling alcohol. High operating cost.
Injection of glycol.....	Simple system involving little or no gas consumption. Relatively little equipment involved. Under ideal conditions lower operating cost than with mechanol.	Involves mechanical equipment and the necessity of hauling glycol. In large systems initial glycol investment may be large. In the event of line breakage large loss is possible. Potential contamination of glycol.
Glycol dehydration.....	Lowest operating cost. Most positive system. Reduces corrosion by preventing water from condensing. Completely automatic.	Highest initial investment. Most complex of the systems.

Indirect Heaters. Heaters have the advantage that no mechanical equipment need be maintained. Fuel consumption, however, is high and heat is rapidly lost to the ground, requiring multiple units on long flow lines. The author has in fact encountered several cases where a large percentage of the gas would be consumed in heaters to prevent freezing of the remainder.

In certain applications, particularly with short flow lines, heaters may still show advantage although the economics become more unfavorable as the price of gas rises.

By writing a differential heat balance and integrating, the following equation may be used to estimate the fuel requirements and/or the heat loss in the line.

$$\ln (t_2 - t_g) = \ln (t_1 - t_g) - \frac{\pi DUL}{12WCp} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where

t_1 = temperature of gas leaving heater — F

t_2 = temperature of gas after traveling distance L — F

tg = average ground temperature — F

π = 3.1416

D = average pipe diameter — inches

L = length gas travels — feet

w = weight flow of gas — lb per hour

Cp = specific heat of gas BTU/lb — F

U = overall heat transfer coefficient BTU/hr/sq ft — F

A value of 2.0 BTU/hr/sq ft-F is recommended for average soil conditions.[2] In the absence of detailed data the following may be used to approximate tg, the minimum ground temperature.

Area	tg 18 in. cover	tg 36 in. cover
Rocky Mountain.....	25 F	30 F*
Midwest.....	30 F	35 F*
Oklahoma and Texas Panhandle....	35 F	40 F*
East, Central and West Texas.....	45 F	45 F
Gulf coast.....	50 F	50 F

* Add 5 F for each additional foot of cover, up to where the total depth does not exceed 6 ft.

For a given system the necessary gas temperature leaving the heater (t_1) may be determined from equation 1. If this temperature exceeds 180-190 F several heaters at periodic intervals are necessary. The heat required in

EXCLUSIVE

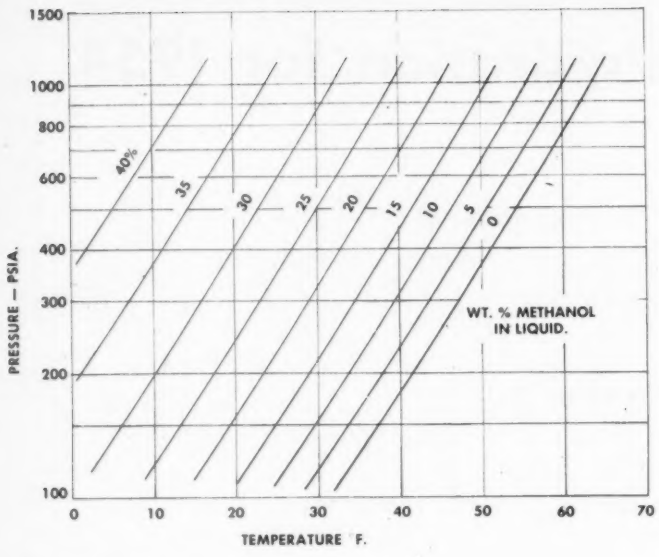


FIG. 1. Concentration of methanol (Methyl Alcohol) required in liquid to prevent freezing.

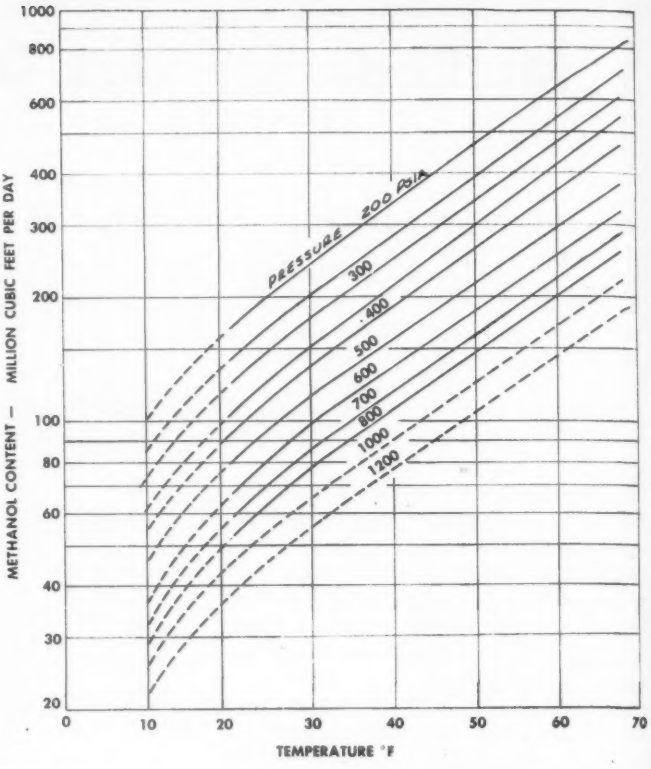


FIG. 2. Methanol content of natural gas at saturation.

the heater may be estimated from readily available data in the literature.[3,4]

Injection of Hydrate Inhibitors. The mechanism of hydrate point depression has been widely discussed since the pioneer work of Hammerschmidt.[5] Although many materials have been used successfully methanol and glycol have received the most widespread use. The former is cheaper and more volatile than glycol but shows disadvantage in economic calculations because effective recovery is not practical. Therefore glycol has received widespread use as a hydrate inhibitor in expansion refrigeration systems.

In long gathering lines, though, the use of glycol is open to serious question for, because of its low vapor pressure, it exists primarily as a liquid. Consequently the dollar value of the residue glycol in the line may be prohibitive. In addition there is a potential dollar loss in the event of line failure. These together with separation and transportation problems make the injection of glycol into pipe lines less favorable than the calculations might show. Certain of these disadvantages are common to all inhibitors, however.

Figs. 1 and 2 represent the data for methanol proposed by Hammerschmidt.[5] The weight concentrations shown in Fig. 1 are based on the hydrate curve for a 0.65 specific gravity gas. For other gravities the curves must be transposed to the right or left.

The pounds of methanol necessary to maintain the proper solution concentration are found by using a water content chart to determine the amount of water condensed as the gas cools in the line, adding any quantities of free water known to be present. To this quantity of methanol must be added that in the gas phase, as shown in Fig. 2.

Fig. 3 shows the amounts of diethylene glycol necessary in the water to inhibit hydrate formation. These curves are based on relatively meager field data and do not represent a complete correlation. Units designed on the val-

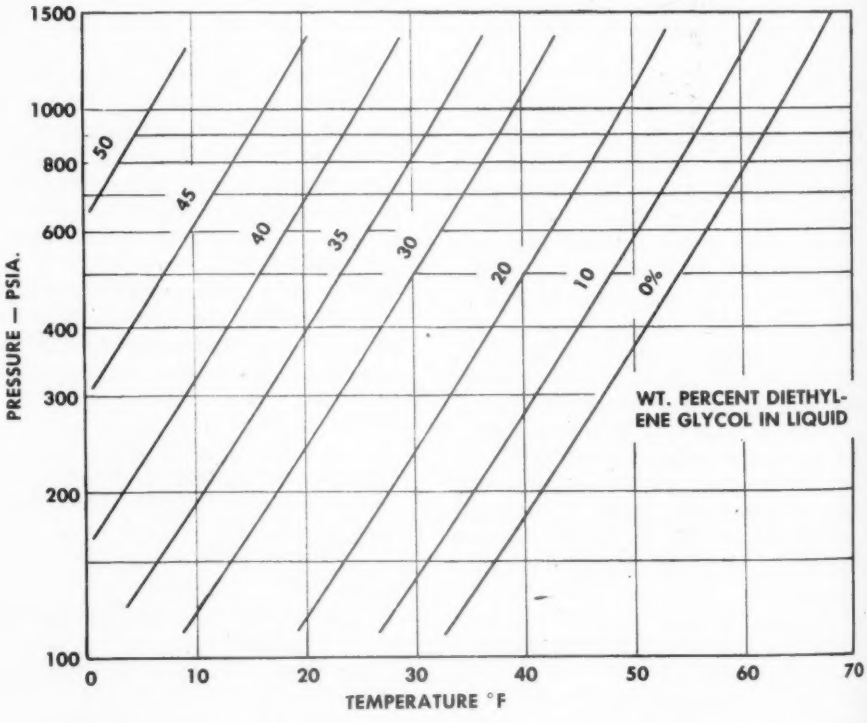


FIG. 3. Concentration of diethylene glycol required in liquid to prevent freezing.

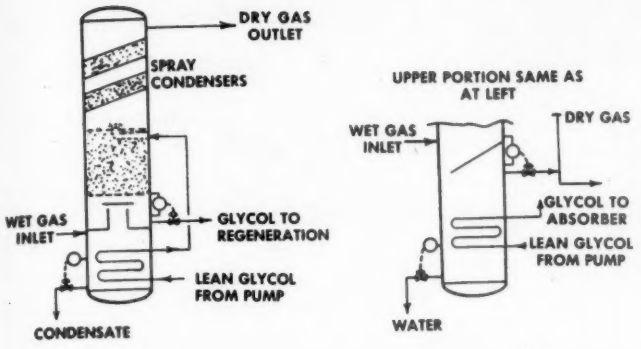


FIG. 4. Two types of sorbers, for gathering system glycol dehydrators.

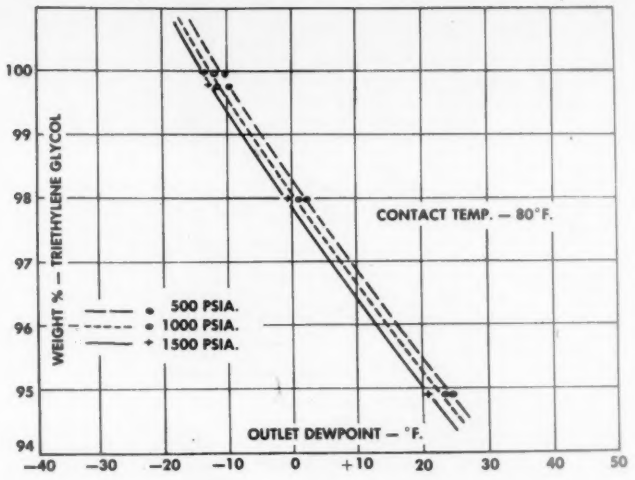


FIG. 5. Effect of lean glycol concentration on equilibrium outlet dew point.

ues shown have operated succesfully, however, showing that they afford safe if not optimum operation. In order to obtain the total requirements of glycol it is satisfactory to assume a vapor loss of 0.12 gal per MMCFD plus 1 gal per 100 bbl of any hydrocarbon liquid produced.

Wellhead Dehydration. The third solution, and the most basic, is to provide positive dehydration. In an attempt to make this approach more attractive dehydrator manufacturers have designed units specifically for such service. Fig. 4 shows two of the approaches used.

Contrary to pipe line dehydration, dew point depressions usually need not exceed 45 F which means that simpler contractors and reboilers become possible. One of the main advantages though has been "weatherizing" to permit cold weather operation. The scrubber portion may be traced with hot glycol to prevent freezing, which at the same time serves as a gylcol cooler.

The best system depends entirely on the individual situation and no one is best for all. In general dehydration shows definite advantage where year around protection is desirable, the gathering lines are long and/or ground temperatures are low. Heaters and/or inhibitor injection find particular application with short lines and where only periodic protection is needed. To be absolutely certain though an economic study is advisable.

The curves in Fig. 5 show the effect of triethylene glycol concentration on the outlet dew point, with an 80 F contact temperature.[7] Comparison of these data with actual field performance of glycol dehydrators operating above 300 psig shows that the equivalent of 85-90 per cent of equilibrium is reached when the contact is furnished by 4 bubble plates, or the equivalent. This then indicates that the dew point depression obtainable by further contact is limited.

Inasmuch as the average glycol reboiler produces only a 96-98.5 per cent solution, which is further diluted in the absorber, far more advantage would seem to be gained by increasing the efficiency of glycol stripping. Consequently in many pipe line applications the expense necessary to produce a 99 per cent glycol solution from the stripper may be justified.

In a gathering system, economics has dictated reducing the amount of contact. By this means space may be economically provided for a scrubber section with little additional cost. Where a 45 F dew point depression is adequate a complete automatic unit may be installed for about 15-20 per cent less than the equivalent unit designed for a 65 F depression, if the cost of an inlet scrubber is included with the latter.

As shown in the right hand diagram of Fig. 4, the scrubber section may be equipped as a free water knockout. All hydrocarbon liquid may then be recombined with the dry gas. This is of particular advantage in gathering systems when central processing systems and/or gasoline plants are installed.

In order to consistently obtain 45 F depressions, countercurrent contact on the equivalent of 2 bubble trays is necessary. When using a 97-98 per cent glycol solution concurrent contact results in simplification of the system but depressions of greater than 40 F are extremely difficult to obtain, without using excessive glycol circulation rates.

Fig. 5 confirms field experience that outlet dew points less than 0 F are difficult to obtain with present regeneration practices, regardless of the contact temperature.

Dehydration Economics

Fig. 6 shows the estimated current applicable prices for dehydration equipment. The curves are for standard pipe line equipment and do not include inlet scrubbers and installation costs. The glycol prices may also be used to predict the cost of gathering system units with combination absorber-scrubbers.

The ratio of dry desiccant to glycol equipment cost is about the same as previously published but the absolute cost of each is about 5 per cent greater. This increase is indicative of general rises in the petroleum equipment field in the past several years.

The higher cost of 500 psig glycol units over 1000 psig is represented by increased glycol circulation and subsequently higher heat load at the lower pressure. At pressures higher than 1000 psig the cost also increases because of the absorber. Consequently, the 1000 psig units represent the lowest cost per MMCFD, as the above costs somewhat compensate for each other.

The cost of 500 and 1000 psig dry desiccant units is comparable.

As the pressure exceeds 1000 psig the increase in equipment cost is relatively rapid because of the increased cost of values and fittings. The rapid increase from 1200 to 1500 psig represents the additional investment for ring joint flanges, heavier nozzles, and high pressure valves.

Dry Desiccant Development

Dry desiccant dehydration has a cost disadvantage that often outweighs some of its inherent process advantages. Most of this cost disadvantage stems from the number of relatively large switching valves needed and the large containers for desiccants. In order to surmount these disadvantages desiccant manufacturers have been

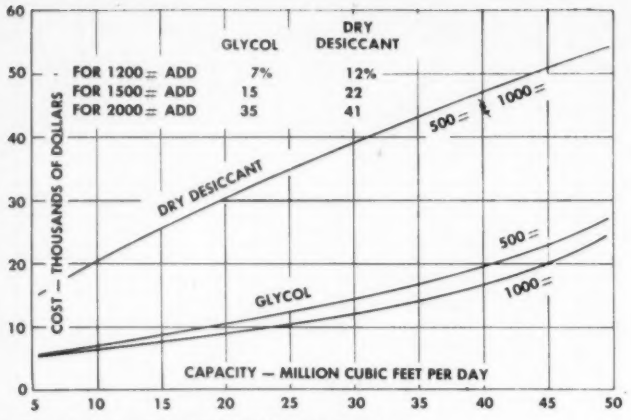


FIG. 6. Approximate initial equipment cost, for dehydration equipment.

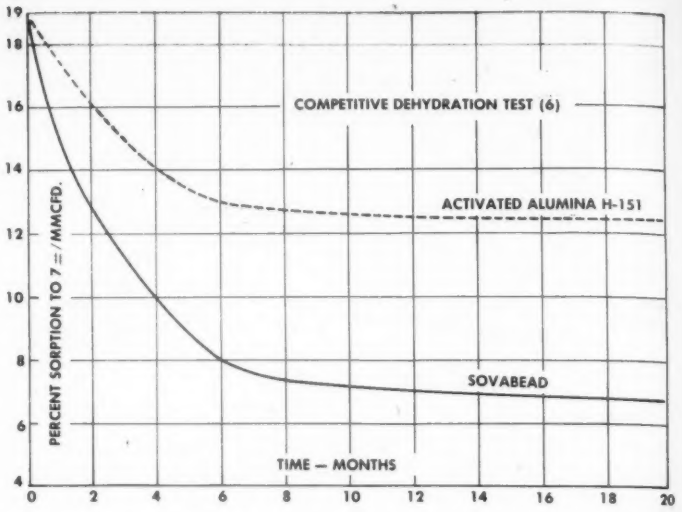


FIG. 7. Reported comparative capacities of two gel type desiccants.

working on desiccants of higher sorptive capacities and continuous systems using fluidized particles.

Some of the latter systems have shown promise but they present some unusual mechanical problems. At the present time the author knows of no such system that has been perfected to a sufficient degree for field operation.

A new desiccant, Activated Alumina H-151, has shown promise. Fig. 7 summarizes some relatively short term test data recently reported in the literature.[6] Other comparative tests are now underway by several companies.

Sufficient operating data are not yet available to establish the advantages and disadvantages of this new desiccant. It is of the gel type and is primarily an alumina gel with some silica present. The manufacturers claim that it has a higher resistance to fracturing in the presence of liquid water than silica gel type desiccants.

The present cost is about 1½ times that of other gel types and about 6 times that of the cheapest bauxite desiccants. This price though will undoubtedly decline as manufacturing facilities increase. It is extremely difficult, if not impossible to establish general comparative economics on dry desiccants because the type used depends on the service and the process requirements.[1] The economics also involves desiccant service life since bed replacement represents a substantial operating cost. The total installed cost, including desiccant, does not vary too much regardless of the desiccant used. The high capacity desiccants cost more but the vessel cost is less.

Because of this the author feels that designing for five per cent sorption and using a cheaper desiccant on the initial charge is the best practice if any doubt exists about the expected desiccant service life. If this unit is properly designed high capacity desiccant may then be added at a later date, if desired. By this means the ultimate flexibility is provided without a cost penalty. In the event of desiccant fouling the cost is further minimized, yet some expanded capacity is possible.

High Temperature Dehydration

As more deep gas wells are drilled it is common to encounter high temperature dehydration problems. Of course an obvious solution would be to locate the dehydrator downstream after the gas had lost heat to the ground but this is often impractical because of terrain, operational problems, and the fact that the degree of such cooling is not controllable. Consequently it is not too uncommon to see dry desiccant dehydrators purchased for the drying of gas above 100 F.

There are undoubtedly circumstances which sometimes justify such a move but if possible cooling is the cheapest means of dehydration above 100 F. Where water is available it is cheapest to cool as low as possible with it before using other means.

In the last two years refrigeration produced by artificial means has become of importance. It is still not feasible to produce pipe line specification gas entirely by refrigeration unless liquid recovery justifies it because the cost per ton increases sharply with lower temperatures. This is shown in Fig. 8. The costs shown are for compression refrigeration systems but the absorption type have comparable costs, for the same temperature level.

In order to reach some conclusions, calculations were made to determine relative costs of dry desiccant dehydration versus water cooling to 100 F, refrigeration to 80 F and glycol dehydration. A flow rate of 10 MMSCF was chosen for study of the project.

The results of this comparison are shown in Fig. 9. The costs in each case include all equipment necessary but no installation since the latter costs should be comparable. About 35 per cent should be added to the costs shown to cover installation.

As temperature increases the dry desiccant cost does likewise because of the increasing gas water content. Said content, for example, almost doubles as the saturation temperature increases from 80 F to 100 F. Consequently larger sorbers and regeneration facilities are necessary even though the flow rate does not vary. If desiccant had been included the slope of the curve would have been slightly larger.

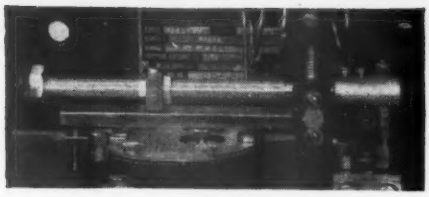
The lower curve is rather steep from 80 F to 100 F, reflecting the greater drying load and the proportional cost of refrigeration. Above 100 F the slope is less pronounced because the cost of water cooling equipment does not increase nearly so proportional to the heat load.

If water were not available the cost of refrigeration only could be estimated by extrapolating that part of the curve from 80 F to 100 F. Although not as much advantage may be shown with water cooling, a net saving results until the temperature reaches about 125 F.

Actually cooling to 90 F is sufficient to produce an ultimate water content of 7 lb per MMCF as long as the pressure exceeds 600 and a high dew point depression glycol unit is used.

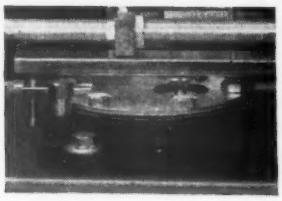
Because of the larger number of equipment alternatives now available a closer analysis of the process needs is necessary to arrive at the best solution. No one type of equipment offers the best solution for all problems and even with the rapid advancement of dehydration techniques, other approaches may sometimes be justified.

PROCESS CHANGES CAN'T OBSOLETE THIS TRANSMITTER . . .



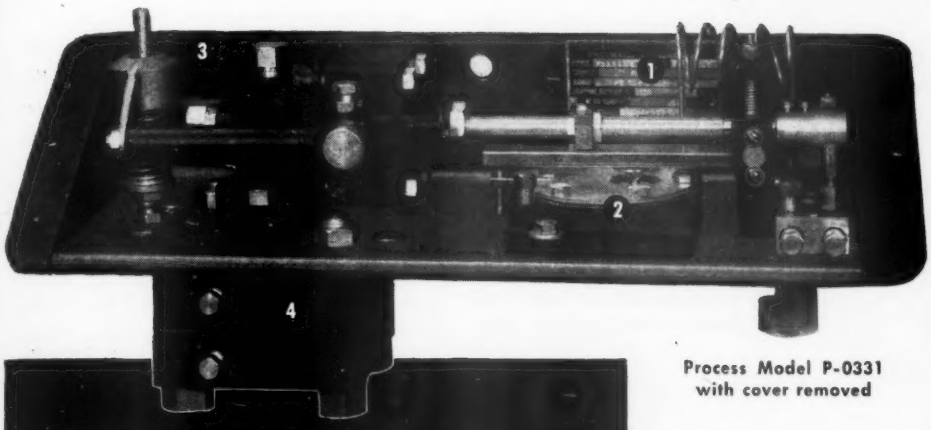
❶ 10-1 RANGE CHANGE —NO CHANGE OF PARTS

Double weighbeam construction on many models permits range changes as much as 10-1, just by turning a set of locking nuts to change a fulcrum point.

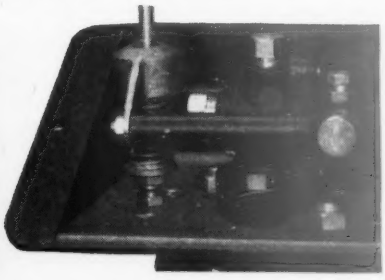


❷ ADDITIONAL 16-1 RANGE CHANGE—STILL NO PARTS CHANGE

Range may be changed on all models by loosening retaining bolts and sliding the reaction chamber to a new leverage position. Reaction area may be changed for further range change.



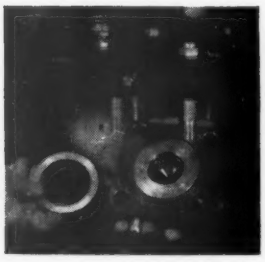
Process Model P-0331 with cover removed



❸ SUPPRESS, COMPOUND OR REVERSE RANGES

Balancing spring, installed to exert either an upward or downward force on transmitter weighbeam, quickly converts transmitter for range suppressions up to 80% of total range, for reversed ranges or for compound ranges where pressure fluctuates above and below atmospheric pressure.

REPUBLIC PNEUMATIC TRANSMITTER with EASY RANGE CHANGE



❹ MAJOR RANGE CHANGES

Range change plates may be easily inserted or removed from measuring chamber to change the effective diaphragm area for major range changes. Similar plates may be used also in the reaction chamber for further range change.

Here's the pneumatic transmitter for measuring differential, flow, pressure or level that saves you time and money when operating conditions are not definitely known or processes are likely to be changed. Extreme flexibility of design lets you adapt the same transmitter chassis for almost any range of measurements—often without any change of parts.

Process Model pictured above has a differential range of 0-12″ H_2O minimum and 0-880″ H_2O maximum at operating pressures to 1500 psig. Other models are available for differential ranges as low as 0-0.6 H_2O or as high as 0-750 psi.

Transmitters may be constructed of special materials to handle almost all types of corrosive fluids. Ruggedly built, they give long service out-of-doors. Accuracy is guaranteed at ½% of full range on standard models.

Republic transmitters are used in process, chemical and petroleum plants all over the country. Investigate their advantages for your plant.

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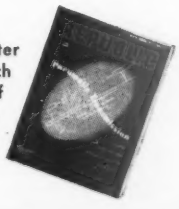
Get the full story about Republic transmitter flexibility. Send for free Data Book which gives all the facts about complete line of Republic transmitters, including Square Root Extracting and Pneumatic Electric models.



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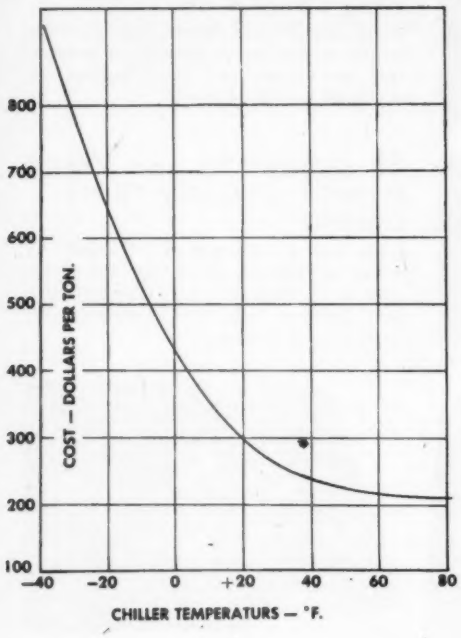

FIG. 8. Effect of chiller suction pressure on refrigeration equipment costs.

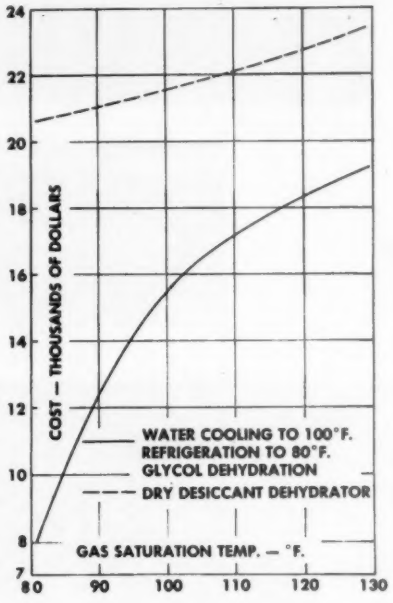

FIG. 9. A comparison of high temperature dehydration costs.

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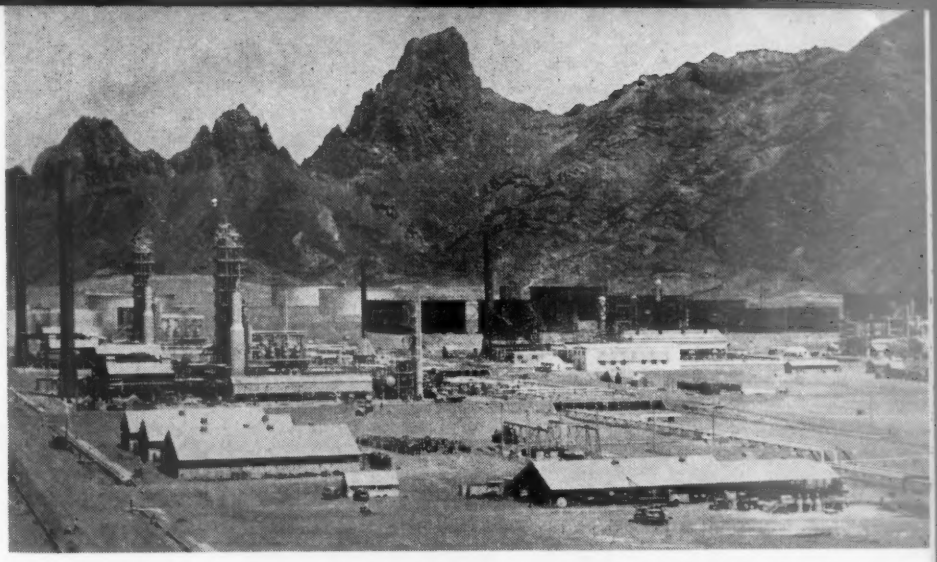

A general view of the refinery area at Anglo-Iranian's new £45,000,000 oil refinery which came on stream on July 29th.

Anglo-Iranian's Aden Refinery Operating

A new refinery, built during the last 2 years along with a complete self-contained new community-municipality, to process 120,000 bbl per stream day has sprung up at Little Aden, across the bay from Aden, on the southern tip of the Arabian peninsula at the southeast end of the Red Sea. Plant is to operate on Kuwait crude to yield a full line of fuel products.

A harbor was built by dredging out sand; work done by a British-Dutch combine. Construction crew included some 14,000 persons of all types, Europeans, American, and Asiatic. The operating organization includes some 250 British and 11,500 Arabs and Indian.

Plant includes 2 primary or crude distillation units, each of 60,000 bbl. per day capacity, that separate straight-run gasoline, kerosine, diesel oil, and heavy fuel oil. The port of Aden is one of the major stations in the Orient, for both coal and oil.

Units have 140 ft, by 16 ft diameter fractionators, made in 3 sections and brought to the site, erected in 7 weeks. Units are said to be the first in the world to be electronically controlled throughout. Power kerosine is made from the kerosine fraction by extracting aromatics with sulfur dioxide. The power kerosine fraction is desulfurized by the AIOC Autofining process. Motor fuel is upgraded by a 12,000 bbl per day Platformer unit operating on low-grade naphtha. Products requiring more treatment get caustic washing, copper sweetening, and/or solutizer treating. Salt water from the bay is used for condenser and other cooling water, can be pumped at the rate of 1,000,000 gal per hour.

Berths for 4 steamers simultaneously are provided in the harbor. Two may tie up at the "finger" jetty, while two "T-Head" jetties handle 2 more. Use was made of the sand, 6,000,000 cu yds from the harbor, by pumping in onto 200 acres of waste land, on which tankage and the port offices now stand.

To connect the refinery with the oil bunkering station across the bay at Aden, two 19-mile long pipe lines are installed; one is 16-in., one 6-in. diameter. More than 40,000 bbl per day of fuel oils will be handled by these lines. "Go devils," steel-rubber plugs that prevent stream contamination, give warning, by radioactive capsules, of the approach of the end of any given stream at the receiving station.

From bunkering station submarine pipe lines connect to 8 off-shore ship loading points. Personnel housing building is continuing; 75 houses for British staff families, along with 100 houses for laborer families are under construction. Staff houses were prefabricated in Britain, and each contains an air-conditioning unit. A second building job is installing 150 houses for Indian married foremen and clerks, 60 for bachelor quarters and 200 for married laborers.

Aden can be considered a natural for a refinery site. Each year 4500 ships stop there and refuel. It is at the eastern end of the Red Sea, opposite end from the Suez Canal, and within reasonable reach of the Kuwait oil felds.

First problem solved in planning for the refinery was to drill test wells in the desert nearby, which found adequate quantities of water for all needed purposes. Water for boilers, for process purposes, and for general personnel and municipal use is drawn from wells 6 miles inland from the plant. Plant and port were built by two companies, Middle East Bechtel Corporation, an American-backed company, and George Wimpey and Company, of Great Britain.

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This Duragauge was named *Maxisafe* because it has an integrally-cast wall to separate the dial from the movement and Bourdon Tube assembly — a solid wall of safety that protects the viewer if the tube ever ruptures. Covering the back of the case is a double spring mounted safety release plate — a Teflon-coated plate tightly fitted on a rubber gasket and held in place by a knurled knob. Less than 0.5 psi pressure created by a ruptured tube forces this cover open — vents the discharge safely to the rear.

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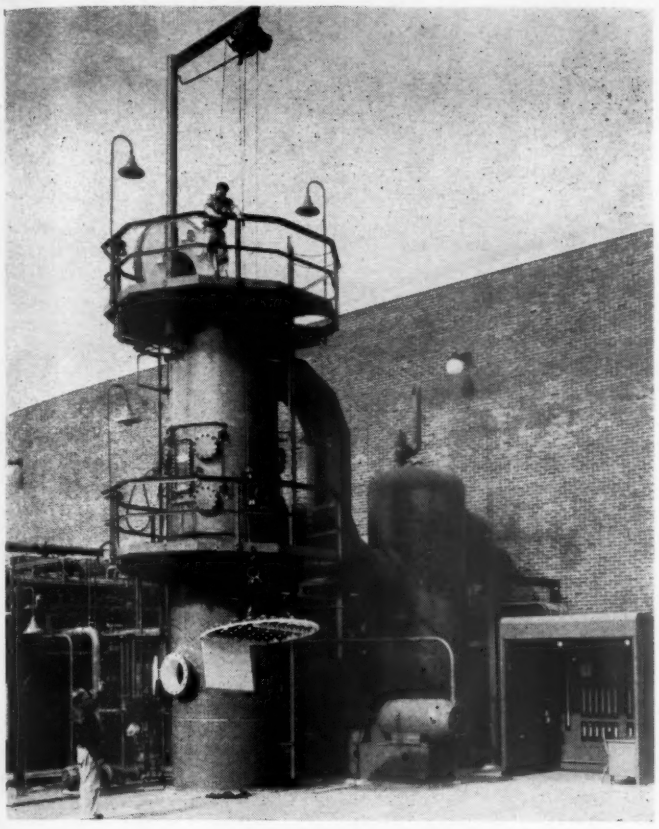


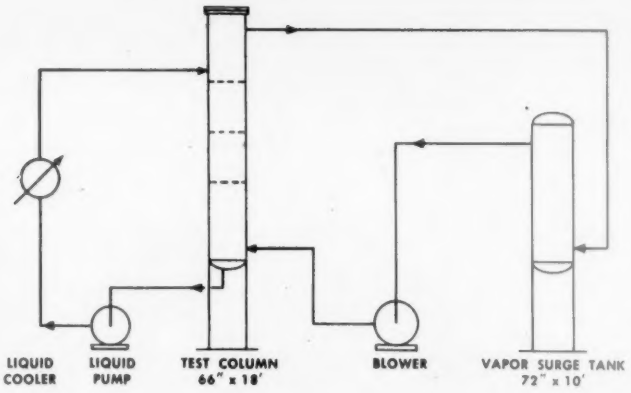


FIG. 1. Flow diagram of the Simulator unit, now being used for research work on fractionation methods.

FIG. 2. The Simulator unit, with assembled fractionator plate being hoisted into the tower.

Joint Research Studies Fractionation Fundamentals

Forty-two companies join hands to discover better methods of hydrocarbon separation

DR. E. H. AMICK*

DISTILLATION, the most widely used method for separating hydrocarbons, was practiced for centuries before it was adopted by the petroleum industry. In view of the long history and extensive use of distillation, it is surprising how little is really known about the design of fractionating columns.

The first step in the design of a fractionating column involves the calculation of the number of theoretical contacts or trays. If vapor-liquid equilibrium data are available, these calculations usually present no problem although they can be very time consuming and tedious. Automatic computing machines are being used in many organizations to reduce the time and effort required. The selection of the type of column internals, the translation of theoretical contacts or trays into actual contacts or trays, and the determination of the column size present the real problems today.

The selection of the type of distillation equipment to be used is now much more of a problem than it was a few years ago. In the decade before World War II and during the war, the petroleum industry used bubble cap trays almost exclusively in commercial size columns. The primary concern was the selection of the type of bubble cap, the layout of the tray, and the sizing of the column. Today consideration must be given to the other types of trays which are available, the proprietary devices, and the different types of perforated trays.

As the literature on distillation is voluminous, it would seem that it should provide a wealth of information on the prediction of plate efficiencies and the sizing of columns, at least for the widely used bubble cap columns. Unfortunately, most of the published experimental data dealing with efficiencies and capacities were obtained in laboratory columns of small diameter; very few data are available on columns of commercial size. Comparisons of data from laboratory columns with those from commercial columns often show wide discrepancies.

Typical of the work on large trays which has been published in the past decade or so is that in which large rectangular plates have been tested by blowing air through the plate and flowing water across it. The rectangular plates were used with the idea that the operation of a commercial size plate could be simulated. In the majority of cases hydraulic gradient and pressure

*Director, Fractionation Research, Inc., Bartlesville, Oklahoma.

EXCLUSIVE

Premier's new 3000 barrel
UOP Fluid Catalytic Cracker

XUM

New Cat Cracker Placed in Operation By Premier

By R. P. Hargis, President
Premier Oil Refining Company of Texas
Longview, Texas

PREMIER Oil Refining Company of Texas recently completed a multi-million dollar expansion program at Fort Worth, Texas, making our refinery there one of the most modern in the entire Southwestern area.

R. P. Hargis

The expansion program was rounded out April 10 when a 3,000 B/SD UOP Fluid Catalytic Cracking unit of the latest design went on stream. It is designed to crack blended atmospheric and vacuum gas oils at a conversion rate of 74 per cent into gasoline having 92 clear research octane rating.

Installation of the cat cracker, with its attendant new polymerization and gas concentration facilities—all three of which were designed and licensed by Universal Oil Products Company—brings to six the number of major processing units in operation at the Fort Worth refinery. Others are a UOP Platforming unit, which has a design capacity of 1,500 B/SD, a thermal cracker, and a crude unit. With these facilities, the Fort Worth refinery has now become self-sustaining. Its supply of crude oil is piped from the Ranger Field into Fort Worth.

Four Reasons for New Unit

Four major factors motivated our thinking about installing a cat cracker less than three years after the company built the UOP Platforming unit. These factors were, in brief:

1. A cat cracker would enable Premier to make greater amounts of high quality finished gasolines; it would open up new avenues for marketing such products as butane-butylene; it would put Premier in the position of converting excess middle distillates into marketable products.

2. It would provide not only the Fort Worth refinery but Premier's other Texas refineries at Arp, Baird and Longview with a choice gasoline blending stock having an F-1 leaded octane number of 98 to 100.

3. It would further improve the refinery's economic position by making possible a larger gasoline yield from the crude run. The overall gasoline yield at the Fort Worth refinery was 52 per cent. It was estimated that with a cat cracker a gasoline yield of 67 per cent could be obtained—an estimate that since has proved to be accurate.

4. A cat cracker would permit operating the refinery at its crude oil capacity of 7,500 B/CD.

Coincident with the unit going on stream, Premier launched an intensive newspaper, radio and TV advertising campaign to introduce its new "Ignition Controlled" ethyl gasoline and "Dynamic" regular gasoline. We are now producing a 95 octane premium gasoline and an 86 regular motor fuel to meet the ever-increasing demands for higher quality gasolines in our trade territory.

We supply approximately 100 independent jobbers and more than 600 retail outlets in an area extending from Shreveport, La., on the east to Abilene, Texas, on the west, and from the Red River on the north to the central portion of Texas on the south.

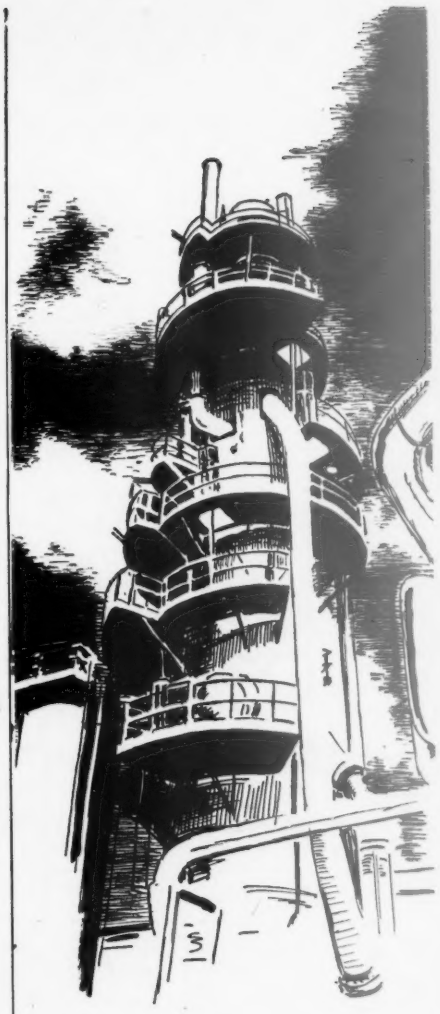
Octane Ratings Increased

Gasoline from the cat cracker is being transported to the Arp, Baird and Longview refineries for use as blending stock. This enables these plants to increase their octane ratings, and puts them in a more advantageous position to meet changing market conditions.

One of the unusual features of our new cat cracker is the placement of the reactor-regenerator on a structural steel skirt instead of having it mounted on a concrete base. Another interesting feature is the suspension of the air heater beneath the regenerator.

All of the pumps and the gas compressors are located under a reinforced concrete structure extending across the battery area parallel to the line of towers. Most of the heat exchangers, surge drums and receivers are placed on the roof of the concrete structure. This arrangement makes for compactness and maximum utilization of space, and enables our operators to control the unit with ease.

With the cat cracker now on stream, we are confident that the Fort Worth refinery is equipped to meet a wide variety of marketing conditions more profitably and with a greater degree of flexibility than was ever possible before.



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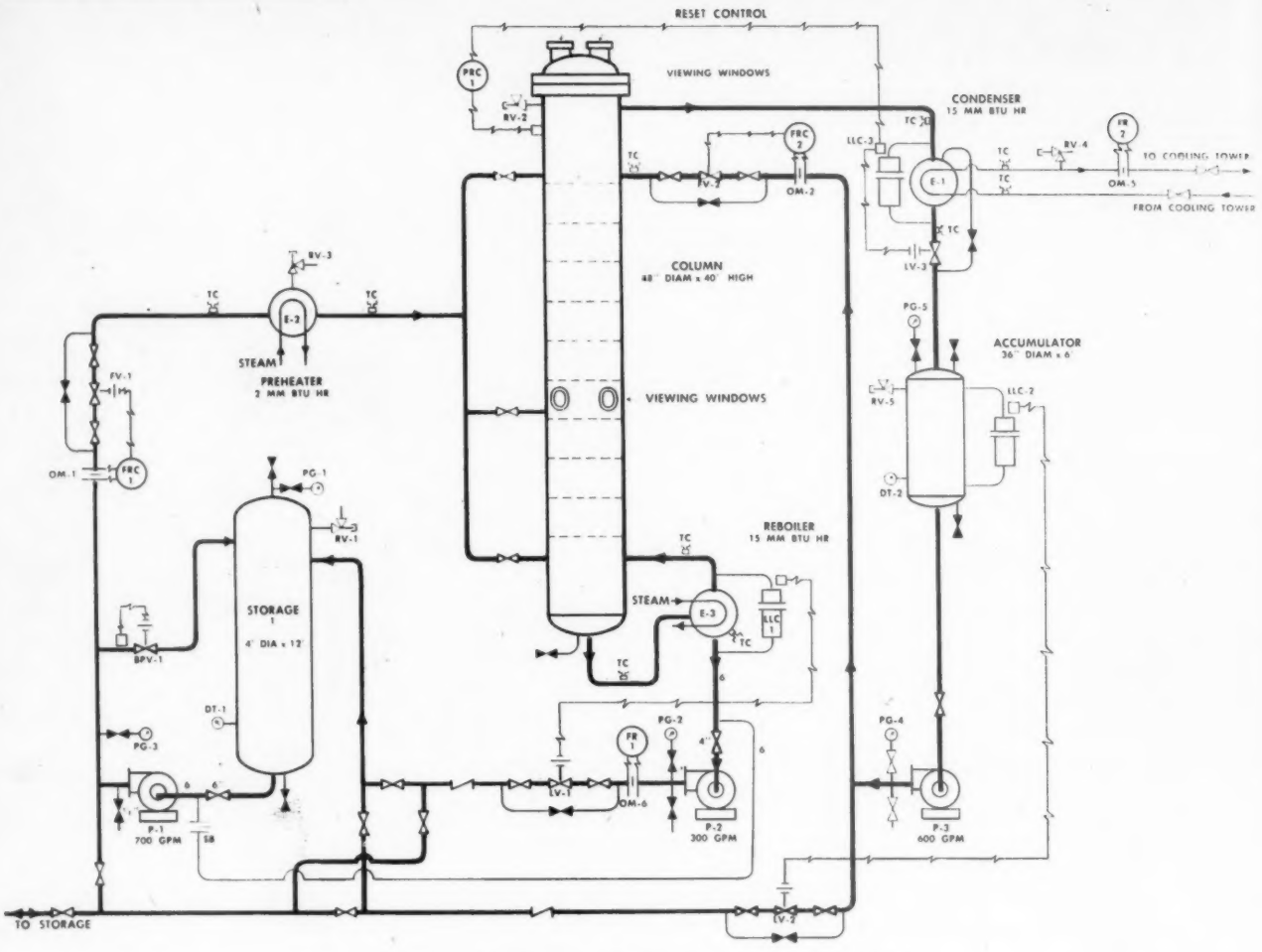

FIG. 3. Flow diagram of the new experimental unit.

drop data were obtained, in some of the cases entrainment data were also obtained.

In most of the work a column with only one tray was tested. The usefulness of data like the above is probably limited as far as the petroleum industry is concerned because the air-water system has quite different properties than hydrocarbon systems. Also, there is some question about the general applicability of data obtained in single-tray columns and from rectangular plates.

As far as is known there are very few companies who have made a concerted effort to obtain the information to enable column capacities and plate efficiencies to be predicted. Even those companies that have done the most work find there are many loopholes in their information. The reasons are easy to discover. The most needed data must be obtained in a column of commercial size.

It is doubtful if plant tests alone would be able to provide all the answers. Even access to a plant column properly equipped for test work in which production could be interfered with so that feed and product compositions and rates could be varied significantly would not be sufficient. The data obtained would only show what the column could do as it was then constructed, not what its real potential might be. If the information is to be obtained in a reasonable time, it is essential to set up an experimental distillation unit which has a column of commercial size.

The investment required for such a unit and its operating cost are greater than most companies can justify. Faced with this situation a number of companies have founded a cooperative research organization, Fractionation Research, Inc., open to anyone interested in the field of distillation and absorption, to plan and carry out a program aimed at obtaining the data necessary for the prediction of the vapor and liquid handling capacity of contacting devices and their separation efficiency at various loadings.

Research Program

It is visualized that when the program is in full swing, there will be in operation both a 3-tray vapor-liquid contactor 66 in. in diameter, and an experimental distillation unit with a column 4 ft in diameter. Also tests will be carried out on a number of plant columns.

Simulator Unit

Work is now under way in the simulator unit, the 3-tray vapor-liquid contactor. Basically, the unit consists of a 66 in. ID column which can hold 3 trays, a knockout drum, a blower, and a circulating pump. Gas can be circulated at rates as high as 15,000 cfm and liquid can be pumped through the unit at 550 gpm. A flow plan of the unit is shown in Fig. 1 and a photograph in Fig. 2.

This unit is designed to secure information on pressure drop, downcomer buildup, entrainment, hydraulic gradient, tray stability, pulsation, dumping, and flooding. The column, as can be seen from the photograph, is well equipped with windows, so a visual evaluation of the contacting efficiency can be made. In addition to the windows in the side of the column, there is a large window in the top head that permits the operation of the top tray to be observed from above. As the gas phase as well as the liquid phase can be recycled through the unit, a variety of gases, and liquids can be used. Test systems that have been used to date are absorption oil- nitrogen-air, absorption oil-methane, absorption oil-carbon dioxide, hexane-carbon dioxide, water-

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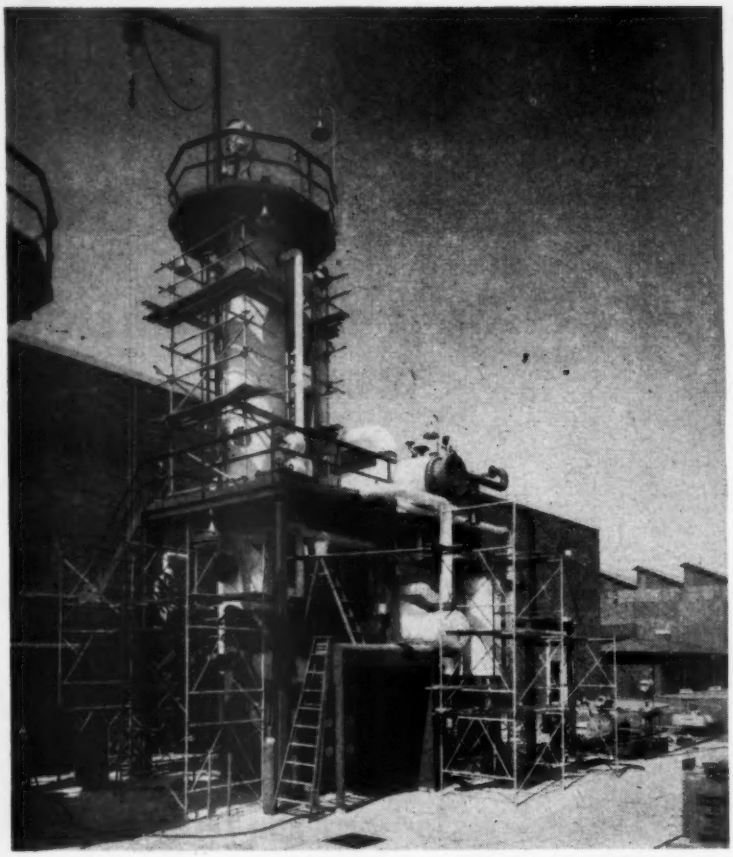

FIG. 4. View of the new experimental tower, also to be used in studying fractionation devices.

FIG. 5. Typical bubble tray assembly for use in experimental tower.

air. Studies on a bubble cap tray with 66 four-inch caps on 5 ¾ in. equilateral triangular centers have been completed. This tray, after minor modifications which the tests have shown to be desirable, will be the first tray studied in the experimental distillation unit. A perforated plate is now under investigation.

The simulator will serve as a screening apparatus to eliminate those trays that do not show sufficient merit to warrant further investigation in the experimental distillation unit. Also it will disclose defects that should be corrected or modifications that should be made in trays before they are tested in the distillation unit. Although the investment for a simulator is high, its operating cost is low and data can be obtained from it rapidly and easily. In a comprehensive research program, considerable money will be saved by using it to complement the work of the experimental distillation unit.

Experimental Distillation Unit

Unquestionably, the most important part of the experimental program of FRI centers around the experimental distillation unit. As far as is known, this is the largest distillation unit that has ever been designed and built specifically for experimental purposes.

The aim, in designing this equipment, has been to provide a flexible unit in which tray operation can be observed, and in which contacting devices can be tested for efficiency to their ultimate capacity with a variety of systems over a wide range of operating conditions. The auxiliary equipment, including the reboiler and condenser, was sized so that contacting devices, which have substantially more capacity than bubble cap trays as they are known today, can be thoroughly investigated. Fig. 3 is a flow plan of the unit and Fig. 4 is a photograph taken of the unit as it was under construction.

The unit is designed so that it will be possible to operate it at pressures from 5 mm of mercury absolute to 150 psig, although at present, it is equipped for operation at pressures from atmospheric to 150 psig. By the addition of vacuum producing equipment and minor modifications, the unit can be operated at sub-atmospheric pressures. The reboiler is heated by steam which is available at 200 psig.

The unit is arranged for recycle of the product streams so as to minimize the amount of feed and product storage required. It can be operated as a stripping, enriching, or conventional fractionating unit. Instrumentation is provided to control reflux and feed to the tower and the steam to the reboiler. Bottoms and overhead products are withdrawn by level controllers in the reboiler and accumulator. The tower pressure is controlled in effect, by regulating the amount of heat transfer surface in the condenser. This is done by a level controller on the condenser which is reset by a pressure controller on the column.

The distillation column, which is 4 ft ID, can hold 10 trays on a 2 ft tray spacing. At the level of tray 4, there are provided 4 nozzles in which windows will be installed. For low pressure work, windows 7⅜ in. in diameter will be used, but for the higher pressures, it will be necessary to use windows which have a diameter of 4 in. A window, visible from the 4 windows in the side of the column, is installed in the appropriate downcomer. This allows the level of liquid and froth in the downcomer to be observed. On the top head of the column are 2 nozzles in which windows can be installed so the operation of the top tray can be viewed. Connections for sample points and thermocouple wells are located at 6-in. intervals along the shell so that it will be possible to get plate compositions and temperatures at all plate spacings.

The distillation column has been provided with a removable head through which tray rings can be in-

serted or removed and, if desired, so can complete trays. A clean-shell type of construction has been employed. As Fig. 5 shows, the trays are supported on tray rings which in turn, are supported on adjustable rods. The bottom ring is supported from brackets welded into the column above the reboiler vapor nozzle. The adjustable rods permit the trays to be spaced as desired between 12 and 36 in. and are the means of leveling the trays. The tray rings are sealed to the tower by the use of asbestos rope packing compressed by a packing ring.

In order to make changes in tray construction easily and cheaply, the trays have been made up in three separate sections, a downcomer section, a downcomer seal section, and a contacting section. In the contacting section are installed bubble caps, or perforated plates, etc. With this construction, it will be possible to study various contacting devices merely by lifting out the contacting sections and replacing them with new ones. This will permit the same downcomer and downcomer seal sections to be used with different contacting devices. Studies of downcomer construction or downcomer sealing can be made by removing and replacing the desired sections leaving the contacting section the same. Envelope-type downcomers are used.

A good deal of effort went into the design of the trays and tray support rings in an attempt to develop an assembly which would permit tray spacing to be changed with a minimum of problems and allow changes of entire trays or parts of trays with a minimum of difficulty. In a tower of this diameter, it is especially important to keep the tray support ring narrow to prevent it from occupying too high percentage of the tower cross sectional area.

Bubble cap and perforated trays will be studied first in this unit, the former because of their widespread use and the latter because of their promise. Also, reliable information on the capabilities of a well designed bubble cap tray are needed to serve as a standard with which other types of trays can be compared.

In recent years a number of proprietary devices, including the Turbogrid tray, the Koch Kaskade and Benturi trays, the Socony-Vacuum Uniflux tray, the Nutter Float Valve tray, the Kittel tray, and Panapak have come on the market. A study of some such devices is to be made in the unit.

In the initial work, several systems will be used in testing the trays. It is believed that sufficient information will be secured on the effect of system properties on such things as liquid and vapor handling capacity, plate efficiency, froth height, build-up in downcomers, and pressure drop so that in subsequent work, tests with one or two systems will be sufficient to characterize a tray.

The first two systems that will be used are normal and iso-butane, and cyclohexane-normal heptane. Other systems that may be used are isopropyl alcohol-water, methyl ethyl ketone-secondary butyl alcohol, and hexane-absorption oil. Although binary systems will normally be used because their analysis is simple and more reliable, sufficient work will be done with ternary and multicomponent systems so there will be no doubt of the applicability of the results to these more complex systems.

The runs on the first few trays will necessarily be comprehensive. Generalizations developed from this work will permit the evaluation of a tray with a minimum of runs. In the early tray studies, runs will be made for each system with pressure constant, at a range of values of the reflux ratio, L/V. At each of the reflux ratios, efficiencies will be determined at 40 to 95 per cent of the flooding capacity. Corresponding runs will be made at other pressures.

Plant Tests

In the third phase of the program, capacity and efficiency tests of commercial fractionating towers and absorbers will be undertaken. These will provide data to check the results of the experimental program and data on systems that cannot be run in the experimental unit. For example, it will not be possible to make either very high pressure absorption or fractionation tests in the experimental unit. A number of companies have expressed their willingness to cooperate in a plant test program so there will be available for test such a large number of columns that it will be possible to select those columns that will provide the maximum amount of usable information.

Conclusion

This is the most extensive program yet undertaken to secure information on vapor and liquid handling capacities and plate efficiencies of columns of commercial size. As a result of this work it will be possible to build new units more economically and to revamp in the most economical way existing units to provide for increased capacities or for changed feed stocks or to meet rigid process specifications.

Turbogrids:

Lower Cost, Higher Efficiency

New design easier to fabricate, show lower pressure drop, and are less subject to fouling than older designs

ENGINEERING STAFF†

A STUDY of fractionation equipment was started several years ago by Shell Oil Company to determine operating characteristics of columns that were in productive service. Most of the columns were stabilizers or gasoline boiling range columns. After completing 15 or 20 test runs, most of which included plate-to-plate efficiency calculations, we found that few firm conclusions could be drawn from the data because of the complexity of structural and operating variables involved.

The second phase of the program was an intensive study of bubble cap trays. A column that is 5 ft in diameter and some 40 ft high was equipped for a wide range of operating conditions and has been used exclusively for experimental studies where variables could be controlled more closely. In general, the experimental data on bubble cap trays indicate that any improvement in efficiency gained by a structural change is offset by a corresponding loss in capacity. Likewise, gains in capacity were usually accompanied by losses in efficiency.

Efforts were then directed toward other means of effecting vapor-liquid contacting. Several tray types, which were a somewhat radical departure from bubble cap trays, were investigated. One tray that has found rather extensive use has been named the Turbogrid tray*. Fig. 1 is a photograph of a new installation in which all of columns are equipped with such trays.

These trays consist of a flat grid of parallel slots, the grid extending over the entire cross-section of a column. The slots can be either stamped perforations in a flat metal plate or may consist of the spaces between parallel bars. Fig. 2 illustrates a typical Turbogrid tray of the parallel-bar type. The structural support framework for the bars, the bottom side of the partly

†Shell Oil Company, Houston, Texas.

*U. S. and foreign patents applied for.

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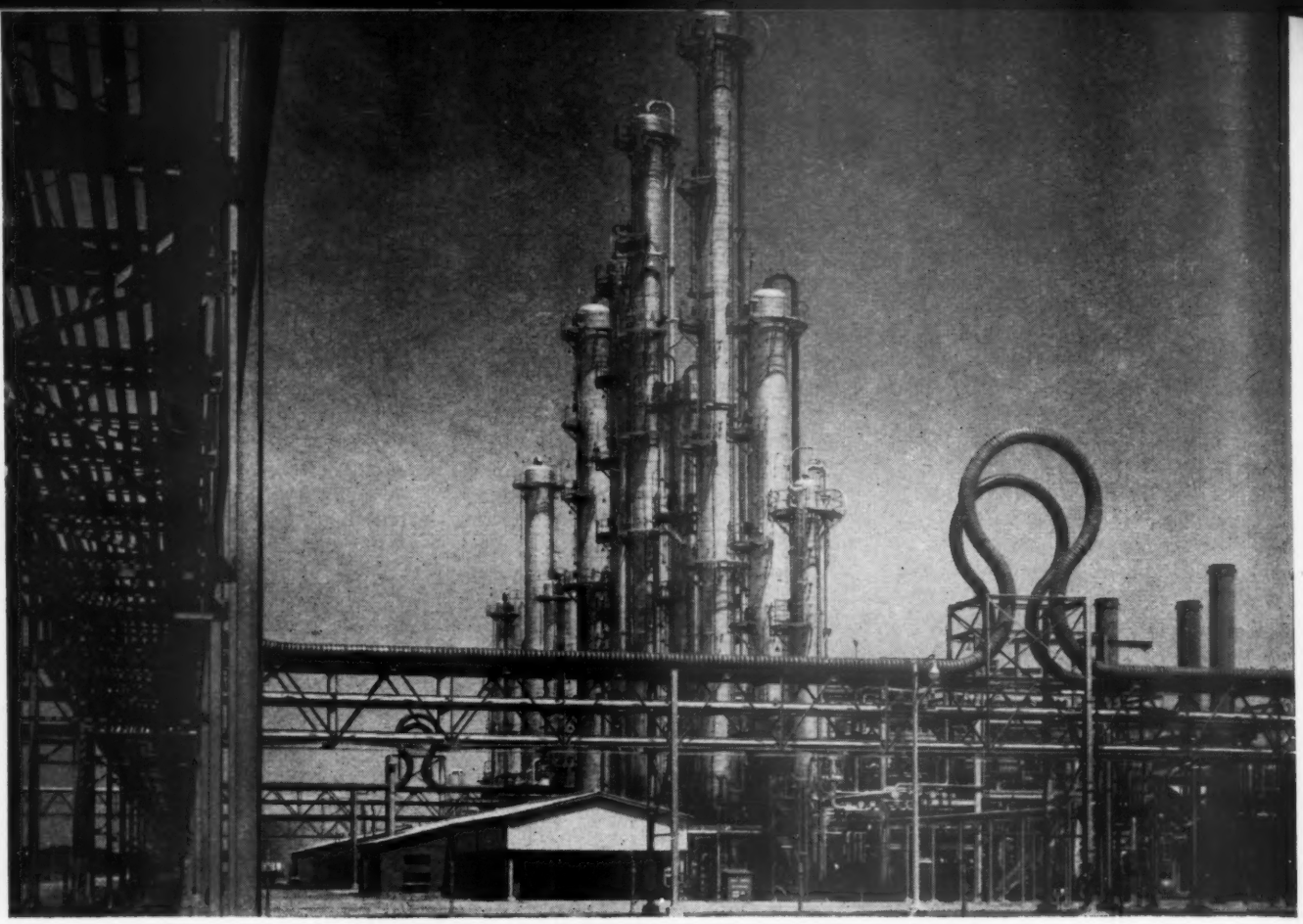


FIG. 1. "Battery" of superfractionators equipped with Turbogrid trays.

completed tray, and the top side of the finished tray are shown. The trays are generally installed without downcomers for liquid flow. Downcomers may be used if desired, but are usually not recommended except for very high liquid rates.

In normal operation of Turbogrid trays, the parallel slots in the trays serve as the passages for both liquid and vapor through the tray. The flow of both liquid and vapor occurs as a cycling or intermittent jet action, uniformly distributed with respect to both phase flows over the entire grid pattern. The interference of the countercurrent flow of liquid and vapor through the tray results in a buildup of liquid on the tray, the liquid holdup being approximately equal to the tray pressure drop. When grid trays are installed with downcomers they perform similarily to conventional perforated trays with downcomers.

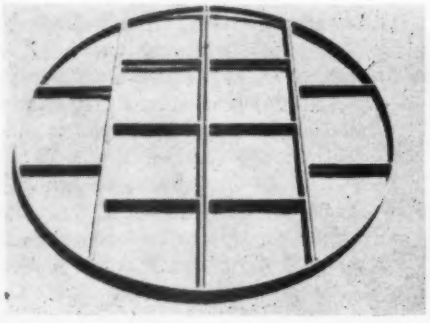
As in other cases, the significant design variables of a grid tray column are the stream properties and rates, the structural details of the tray layout, and the specific requirements of the particular separation process. The structural details that can be varied to meet the flow or process requirements are mainly the slot area in the tray, the slot width, and tray spacing.

The open area is selected to provide the optimum economic balance between tray capacity, efficiency, and operating range. Other factors, such as pressure drop limitations will also affect the selection of the tray free area. In some cases, holdup requirements govern the structural design of the trays. Where tolerance to corrosion or fouling is desired, slot width, and to a lesser extent bar shape, in bar-type trays, become factors to be considered.

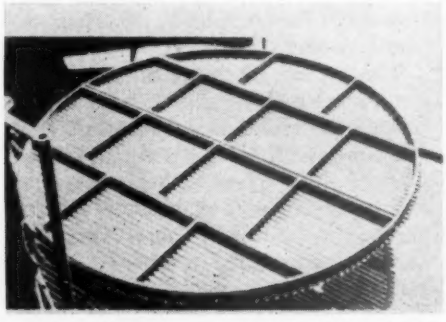
The tray spacing selected represents a compromise between the factors of tray accessibility, and the relative importance of column height and diameter. Tray spacings of 12 to 18 in. normally are used in Turbogrid installations, with 18 in. tray spacing being preferred in large columns to improve tray accessibility.

The operating performance of grid trays as compared to that of bubble cap trays is discussed in the following examples. As an illustration of the general performance characteristics of grid

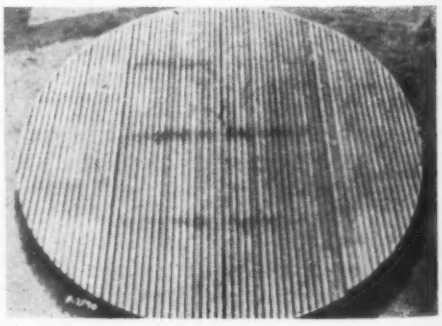
FIG. 2. Typical layout of Turbogrid trays.



Structural framework for grid tray (framework cut into four sections in final assembly).



Bottom side of partly completed tray (welding and trimming of bars and sectioning of tray incomplete).



Top side of completed tray.

trays, the data from the 5-ft diameter experimental column are shown in Fig. 3. Efficiency is expressed in terms of theoretical plates per foot of column height. The bubble cap tray used as a basis of comparison was a round cap cross-flow tray at 18-in. tray spacing. The grid tray was at 12-in. tray spacing.

The curves are average values for stripping, rectifiying, and total reflux conditions. The bubble-cap tray gives a peak efficiency at about 70 per cent of load point and gives lower efficiency on either side of this throughput. The grid tray gives about 35 per cent more capacity than the bubble-cap tray and gives a continual increase in efficiency up to the load point. Above about 80 per cent of bubble-cap tray load point (60 per cent of grid tray capacity) the grid tray efficiency is higher than for the bubble-cap tray; below this capacity the grid tray efficiency is poorer.

Grid trays generally are not recommended for installations that are expected to meet very low loading conditions, say from 25 to 50 per cent of load point. In the normal design region, however, from 60 to 100 per cent of load point, grid trays give superior performance.

The remainder of these cases to be discussed are plant columns that are operating in light hydrocarbon service. The performance of two deethanizers is illustrated in Table 1. Deethanizer A contains 30 grid trays at 12-in. spacing which replaced 22 bubble-cap trays at 16 and 24-in. spacing. The function of the column is partial deethanization of a thermally cracked stream. Operating pressure is 500 psig and vapor density is about 5 lb per ft.

The original bubble cap installation performed satisfactorily at feed rates up to 5000 bbl per day; at higher feed rates the column would not operate satisfactorily unless the reflux rate was reduced, thus adversely affecting separation. The recovery of C_2's in the top and C_3's in the bottom is shown for the 2 types of trays — the bubble cap trays at 4800 bbl per day feed and grid trays at 5000 to 7400 bbl per day feed. Separation is about equivalent, even with up to 50 per cent higher thruput in the grid tray column.

Deethanizer B is the only plant installation using grid trays with downcomers. Sixteen grid trays replaced an equal number of bubble cap trays in the stripping section. The rectifying section remained unchanged. Because of mechanical difficulties in removing downcomers welded to the column shell, the area of the tray covered by bubble caps was removed and grid sections installed. The purpose of the installation was to increase column capacity.

Separation cap was not sacrificed at rates 25 per cent in excess of those limiting the bubble cap trays. The data in Table 1 are typical for both the bubble cap trays and the grid trays operating at 25 per cent higher thruput. The actual limiting load for the grid trays has not yet been reached but is estimated to be some 35 per cent greater than the previous trays.

The bubble cap trays in the stripping section of a depropanizer were found to be considerably damaged by corrosion when the column was opened for routine inspection. Replacement of the existing trays with new bubble cap trays would have been prohibitive costwise because of downtime. Nineteen grid trays were designed, fabricated and installed in six working days.

Table 2 shows a comparison of the separation with bubble cap trays and with Turbogrid trays. In terms of propane and butane recoveries, column performance was slightly improved by the installation of grid trays in the stripping section. Essentially this same separation has been achieved for feed rates between 2000 and 5000 bbl per day. A test run, including plate-to-plate calculations, was made at 2500 bbl per day feed and 2900 bbl per day of reflux. This corresponds to 60 per cent of capacity for the grid trays whose efficiency was calculated to be 60 per cent.

TABLE 1. Deethanizer service.

Deethanizer A	Bubble cap	Turbogrid
Number of trays	22	30
Feed rate b/d	4800	5000—7400
Ethene recovery in tops, per cent	59	66
Ethane recovery in tops, per cent	49	45
Propene recovery in bottoms, per cent	95	95
Propane recovery in bottoms, per cent	97	98
Deethanizer B		
Typical separation for both turbogrid and bubble cap trays		
	Recovery in tops per cent	Recovery in bottoms per cent
C_2 and lighter	98.8	1.2
C_3 and heavier	10.3	89.7

TABLE 2. Depropanizer.

	Bubble cap	Turbogrid
Number of trays*	14	19
Propane recovery in tops, per cent	98.9	99.3
Butane recovery in bottoms, per cent	97.7	98.2

* Bubble cap trays of stripping section only were replaced with Turbogrids.

TABLE 3. Debutanizer.

	Rectifying section		Stripping section	
Feed B/D	Capacity, per cent	Turbogrid efficiency, per cent	Capacity, per cent	Turbogrid efficiency, per cent
7,300	28	26	30	44
10,400	39	40	64	62

The final column to be reviewed is a 6-ft diameter debutanizer with 34 grid trays. Installation was made because of an expected increase in refining thruput beyond that which could be processed in the original bubble cap tray column. The data from 2 test runs shown in Table 3 were taken after the grid trays were installed but before the feed rate reached the level for which the trays were designed. It is seen that over this range, the tray efficiency is roughly equal to the per cent of capacity.

As stated previously, the use of grid trays below about 50 per cent of capacity generally is not recommended; however, the separation achieved in this column at the low rates has been acceptable from the viewpoint of the operating department. The tray efficiencies obtained in the test runs are substantially in agreement with those which would be predicted by the grid tray design procedure.

In summary, the Turbogrid tray has demonstrated decisive advantages over bubble cap trays both in direct comparisons on the experimental column and in comparisons on plant columns in productive service. As compared to bubble cap trays, grid trays operate at a lower pressure drop, are lower in original cost, easier to design and fabricate, and are less subject to fouling.

Turbogrid trays are available to industry through license from Shell Development Company, New York. * *

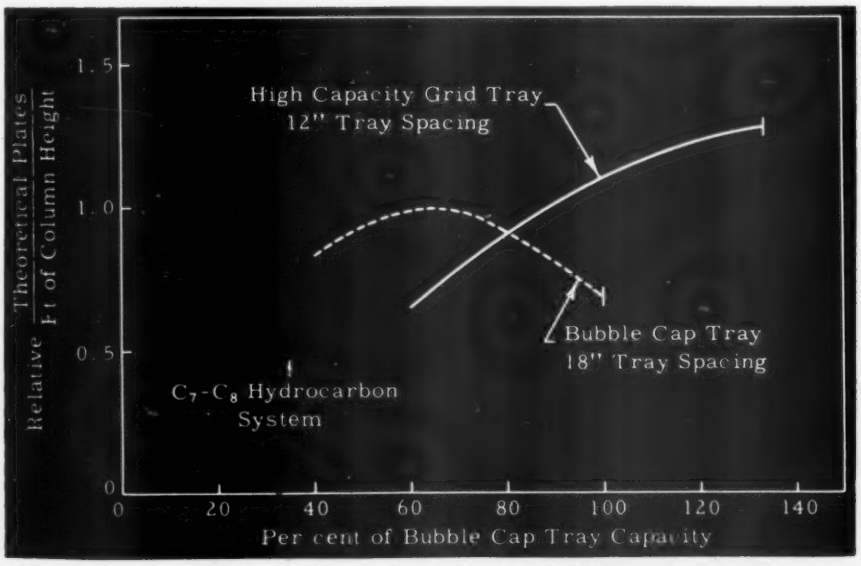


FIG. 3. Curve showing comparison of Tubogrid and bubble tray performances.

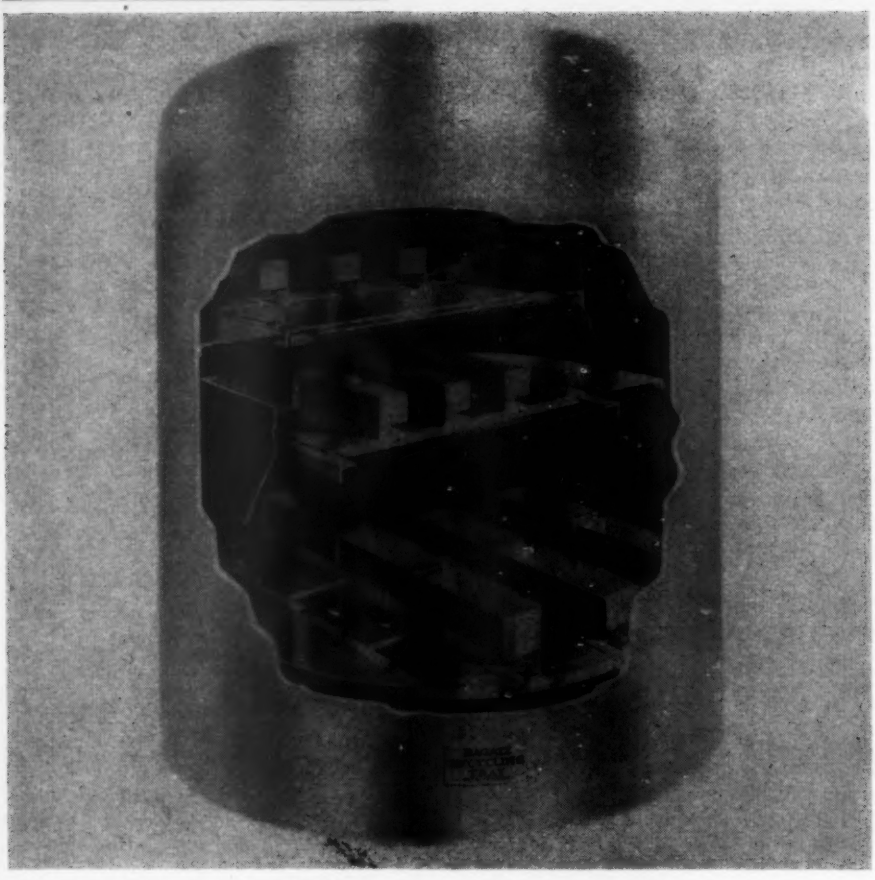


FIG. 1. Cutaway view showing details of recycling tray construction.

The Recycling Tray

Deficiencies in absorber tray performance are corrected by this highly efficient new development

EDW. G. RAGATZ*

DURING the last several years, process engineers have become increasingly conscious of substantial deficiencies in conventional bubble-cap tray performance. As a result, a considerable number of alternate vapor-liquid contacting trays have been developed and offered to industry — with their major stress being usually laid on increased column capacity.

While high capacity is an important objective in any tray design, in many process operations the potential returns from increased tray efficiency are of such magnitude that attainment of maximum tray efficiency becomes paramount, irrespective of the resultant effect on tray capacity. Under such circumstances, to focus on mere capacity "as such" is to overlook the Basic economics of this important class of operation.

The natural-gasoline plant absorber presents an excellent example of high reward to be attained through increasing of currently-employed tray efficiencies. At the recent NGAA forum on "Tray Design," and in a subsequent technical article,[1] details were presented of a new tray specifically designed to provide substantially increased recovery efficiencies for today's high-pressure, high-recovery absorbers.

*Manager of Edw. G. Ragatz Company, San Marino, California.

EXCLUSIVE

This new tray is known as the Recycling Tray, and derives its name from its unique construction and action.[2]

The essential details of the recycling tray construction are presented in Fig. 1. Conventional side downcomers are employed on alternate sides of the column as in the usual bubble-cap structure — with these items being normally permanently welded in the column shell.

The "active" portion of the tray (situated between liquid receiving-plate and off-flow weir of the downcomers) consists of several appropriately-perforated 14-16 gage plates over which are positioned a series of "recycling" baffles. These baffles are interposed in several parallel rows transverse to the path of the cross-flowing liquid, with alternate strips of "free" perforated plate being left between the baffle rows. The baffles rest directly on the perforated plates, and blank off all underlying perforations.

Perforated plates and baffles are removably bolted to angle supporting-grids, and are sized to go through conventional 18-20 in. manholes. The supporting-grids are permanently welded in the column shell, and so proportioned that removal of a perforated-plate section and its overlying baffles provides ready man-way access to all portions of the column structure.

The recycling-baffles proper consist of elongated "box-like" structures of such length as to permit of ready handling inside the column shell. A series of holes are provided in the downstream side of each baffle tangent to the box-bottom, while an open "slot" is provided in the upstream side of the baffle just above the box-bottom. The upper edges of the baffles are normally carried at the same elevation as the top of the over-flow weir, and of sufficient extent to provide the desired liquid residence-time on the tray.

With the alternate perforated-plate "strip" and recycling-baffle "row" arrangement of the recycling tray, the tray liquid traverses several alternate zones of gas-contact and froth-coalescence as it flows across the plate from downcomer inlet to off-flow weir outlet. Through coalescence at adjacent downstream recycle baffles, a substantial portion of the frothy liquid leaving each gas-liquid contacting zone is recycled back via the baffles' upstream "recycling slots" into the *bottom* of the contacting-zone from whence it came for re-contacting therein with additional vapors.

At the same time, another smaller portion of the coalesced liquid flows forward via the baffles' downstream holes into the *bottom* of the adjacent downstream contacting zone. Through such repeated froth trapping, froth co-

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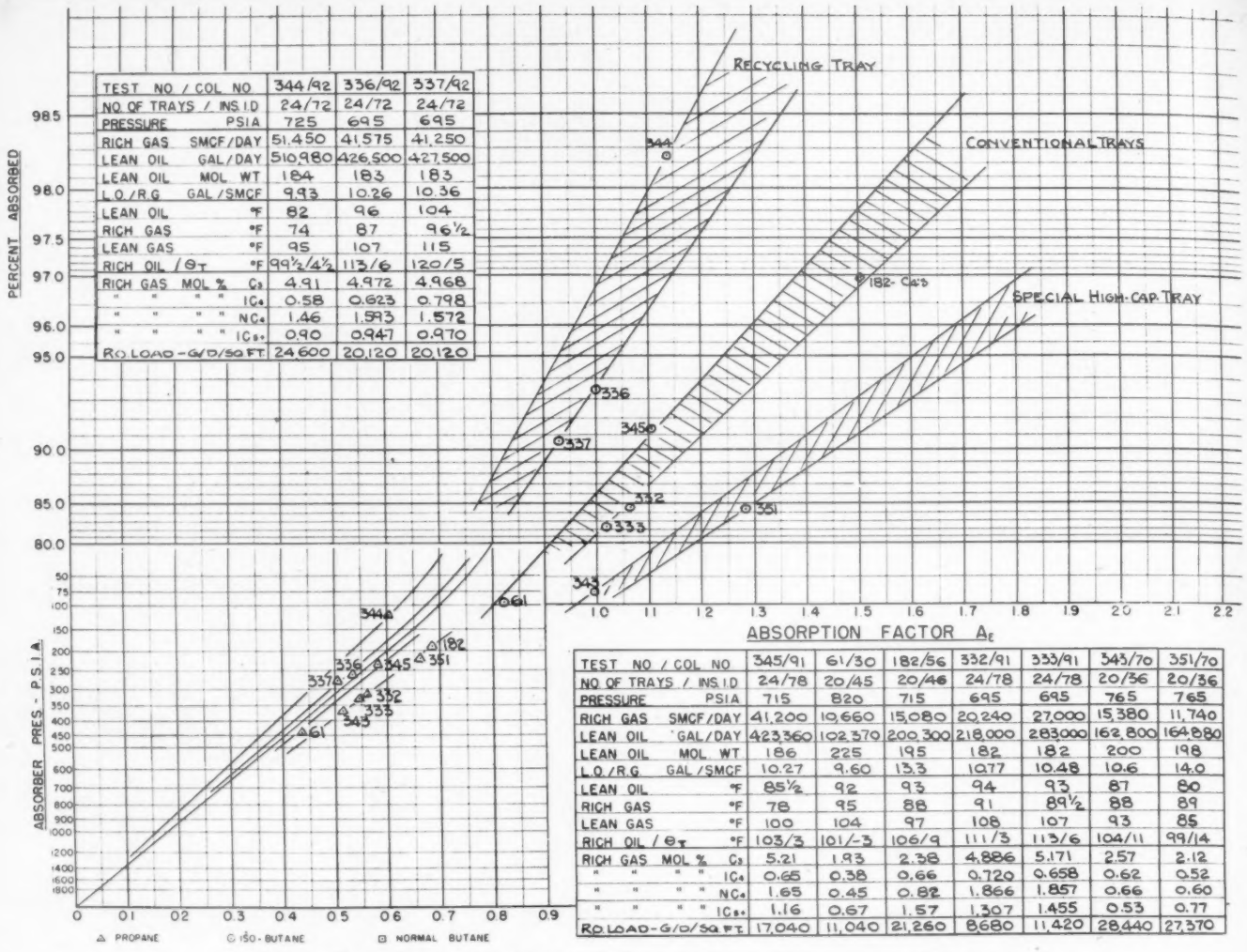


TEST NO / COL NO	344/92	336/92	337/92
NO OF TRAYS / INS.ID	24/72	24/72	24/72
PRESSURE PSIA	725	695	695
RICH GAS SMCF/DAY	51,450	41,575	41,250
LEAN OIL GAL/DAY	510,980	426,500	427,500
LEAN OIL MOL WT	184	183	183
L.O./R.G GAL/SMCF	9.93	10.26	10.36
LEAN OIL °F	82	96	104
RICH GAS °F	74	87	96½
LEAN GAS °F	95	107	115
RICH OIL / Θ_T °F	99½/4½	113/6	120/5
RICH GAS MOL % C_3	4.91	4.972	4.968
" " " " IC_4	0.58	0.623	0.798
" " " " NC_4	1.46	1.593	1.572
" " " " IC_{5+}	0.90	0.947	0.970
RO LOAD - G/D/SQ FT	24,600	20,120	20,120

TEST NO / COL NO	345/91	61/30	182/56	332/91	333/91	343/70	351/70
NO OF TRAYS / INS.ID	24/78	20/45	20/46	24/78	24/78	20/36	20/36
PRESSURE PSIA	715	820	715	695	695	765	765
RICH GAS SMCF/DAY	41,200	10,660	15,080	20,240	27,000	15,380	11,740
LEAN OIL GAL/DAY	423,360	102,370	200,300	218,000	283,000	162,800	164,880
LEAN OIL MOL WT	186	225	195	182	182	200	198
L.O./R.G GAL/SMCF	10.27	9.60	13.3	10.77	10.48	10.6	14.0
LEAN OIL °F	85½	92	93	94	93	87	80
RICH GAS °F	78	95	88	91	89½	88	89
LEAN GAS °F	100	104	97	108	107	93	85
RICH OIL / Θ_T °F	103/3	101/-3	106/9	111/3	113/6	104/11	99/14
RICH GAS MOL % C_3	5.21	1.93	2.38	4.886	5.171	2.57	2.12
" " " " IC_4	0.65	0.38	0.66	0.720	0.658	0.62	0.52
" " " " NC_4	1.65	0.45	0.82	1.866	1.857	0.66	0.60
" " " " IC_{5+}	1.16	0.67	1.57	1.307	1.455	0.53	0.77
RO LOAD - G/D/SQ FT	17,040	11,040	21,260	8,680	11,420	28,440	27,370

FIG. 2. Comparisons of typical absorption-recovery performance, at 650-850 psia.

alescence, and coalesced-liquid recycling, all portions of the liquid stream are brought into effective component-exchange contact with their proportionate share of uprising vapors — irrespective of the flowing oil/gas volume-ratios employed.

As with perforated-plate trays generally, the vapor-liquid contacting effect is enhanced by all portions of the gas-stream being equally well dispersed, and held in the contacting zones for substantially equal portions of time. At the same time, contact with the cross-flowing liquid is increased in effectiveness over the simple perforated-plate operation, by the *parallel* flow of vapors and liquid effected in the contacting zones through the above-noted repeated introduction of coalesced liquid into the *bottoms* of the contacting zones.

Fig. 2 presents typical comparative Straight-Line Chart test data on absorbers operating in the 700-850 psia range while employing the new recycling tray, the best of conventional bubble-cap trays, and one of the recently-developed special "high-capacity" trays.

All of these tests are for operations in which iso-butane was the "key" component — with the iso-butane absorption-recovery ranging from 70 to 98.25 per cent. Comparative operating zones for iso-butane recovery with the 3 tray-types have been defined on the chart by 3 tests on a recycling tray column, 5 tests on 3 "best operating" bubble-cap tray columns, and 2 tests on the special "high-capacity" tray column.

While the relative iso-butane recovery efficiencies of the three tray-types is immediately evident from the position of their cross-hatched operating zones on Fig. 2, it is particularly interesting to note the relative recoveries shown by tests Nos. 336, 333, and 343 operating at almost identical absorption factors. With only negligible adjustments to a common absorption factor of 1.0, these 3 tests indicate actual iso-butane recoveries of 93½, 81½, and 72½ per cent respectively, for the same absorption-recovery potential.

A similar spread in propane recovery is also indicated, although in this case we find the propane-recovery efficiencies of the "high-capacity" tray lining up with those of the "lower boundary" bubble-cap trays. As an example of the similar propane recovery spread, at an interpolated absorption factor of 0.55 we find an indicated difference in actual propane recovery between the best recycling tray operation and the combined high-capacity and bubble-cap tray operation of (62.5 — 48.5) = 14 per cent for the same absorption-recovery potential.

Actual absorption-recovery differences of such magnitude for the same absorption-recovery potential are obviously of primary economic significance.

Fortunately, the recycling tray not only achieves the high-efficiency recoveries typified by the Fig. 2 data, but also combines them with tray capacities substantially higher than employed in the majority of today's conventional-trayed columns.

References

1. "Recycling Tray Boosts Efficiency of Absorption Columns," *Oil and Gas Journal*, April 26, 1954.
2. Both the construction and operation of the recycling tray is fully covered by domestic and foreign patent applications. ★ ★ ★

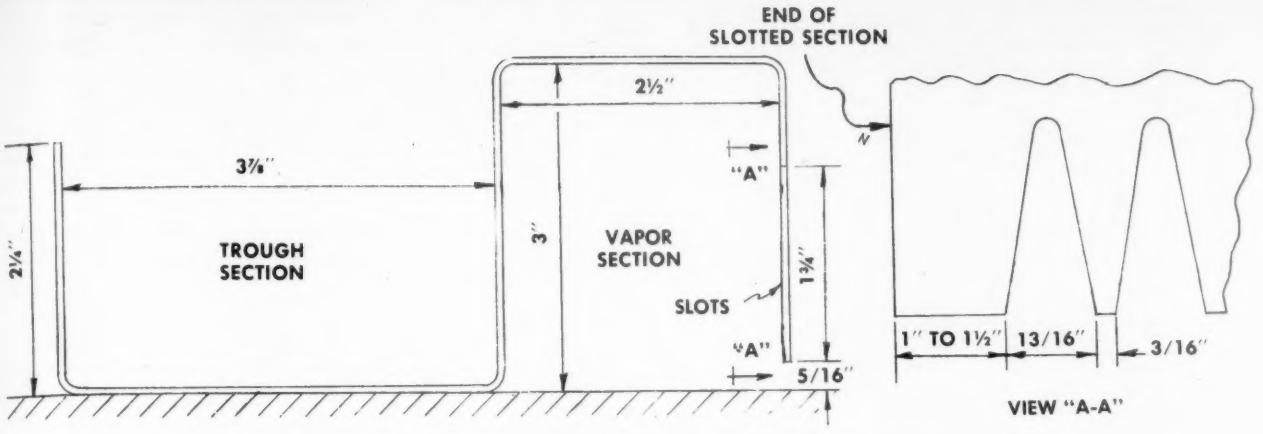


FIG. 1. The "S" Unit, fundamental member of the Uniflux tray.

The Uniflux Fractionating Tray

Simplicity of design, low construction cost, high efficiency obtained in new slotted tray

ENGINEERING STAFF*

As have other operators and designers of fractionating equipment devoted considerable attention to the development and improvement of fractionating tray design, so have Socony-Vacuum engineers over the past several years. The result has been the development of the Uniflux fractionating tray. The Socony approach to this problem has been to develop a radically new and different vapor-liquid contacting device, but to develop a tray employing the same general principles as bubble cap trays which corrects some of the faults in conventional bubble cap tray design and at the same time is simple, adaptable and inexpensive.

Socony Uniflux fractionating trays perform in substantially the same manner and have many of the same characteristics as conventional bubble cap trays. As the design of these trays combines functional and mechanical features, the tray is light in weight and is therefore less expensive than comparable bubble cap trays. It is of simple design and can be installed rapidly in fractionating towers and easily removed if necessary for maintenance inspection and cleaning.

The fundamental unit of the Uniflux tray is the S member (Fig. 1). The vapor section of each S member is enclosed at each end by vapor closure pieces. Intermediate stiffeners are fastened at specified intervals in the trough section, to insure a good section modulus to the member, especially to the free wall of the trough section. These vapor closure pieces and tray stiffeners are slotted so that on assembly the S members are imbricated as shown in Fig. 2. Thus the basic S member has structural, as well as functional properties. When fabricated of 16-gage material, it has ample strength to span a 10 ft diameter tower with negligible deflection under operating and maintenance conditions.

In larger towers (up to 20 ft diameter) a single intermediate support beam is used. No other support beams or purlins are required. These S members are secured to conventional support rings by a single conventional tray clamp at each end. The general assembly of a single cross flow Uniflux tray may be seen in Fig. 3. It may be seen that the S members are assembled starting from the trough at the down-stream side of the tray. The last vapor section is fastened to the vertical flange which is a part of the segmental section at the foot of the downcomer.

For trays having more than 7 S members, a split S member is provided on alternate trays so that vertical access is provided for maintenance, cleaning and inspection. Downcomers are similar to those of conventional bubble cap trays, except that they are standardized with Uniflux trays and are so designed that unrestricted downflow is insured. For trays of very large downflow requirements the vertical flange of the segmental section at the inlet side of the tray is extended upward to provide a proper seal for the downcomer at the inlet to the tray. Double cross flow trays employ the same basic S member elements and are of similar design to the single cross flow design just described.

The tray parts are so proportioned that the available slot area is about 12-14 per cent of the superficial tower area, or generally equivalent to that provided in conventional bubble cap tray designs. As the slotted sections are well separated, there is no interference of the vapors issuing from one slotted element with those issuing from another and the entire length of the slotted sections is fully effective. Furthermore, the vapors issue forth in one direction and in such a manner as to boost the liquid across the tray and compensate for hydraulic gradient hydraulic gradient under all conditions of flow. Therefore, running slot submergence is uniform across tray.

Riser area in general averages two to four times the riser area provided in bubble cap tray designs. Likewise, reversal area and equivalent annular area are large. From data developed to date with the Uniflux tray it appears evident that the combination of equal slot submergence (compensated hydraulic gradient), low pressure drop and elimination of areas of interference will usually result in measurable performance advantages.

Socony Uniflux trays fabricated of 16-gage material, complete with downcomers, weigh about 8 lb per sq ft of superficial tower area. Fabrication is very simple and can be accomplished with standard press brakes, shears, and die stamping equipment found in many

*Socony Vacuum's refining engineering division.

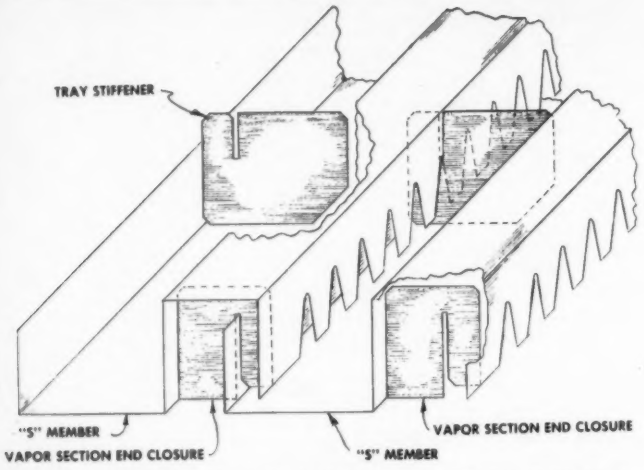


FIG. 2. A graphic view of typical tray sections, showing how "S" members are imbricated in the tray assembly.

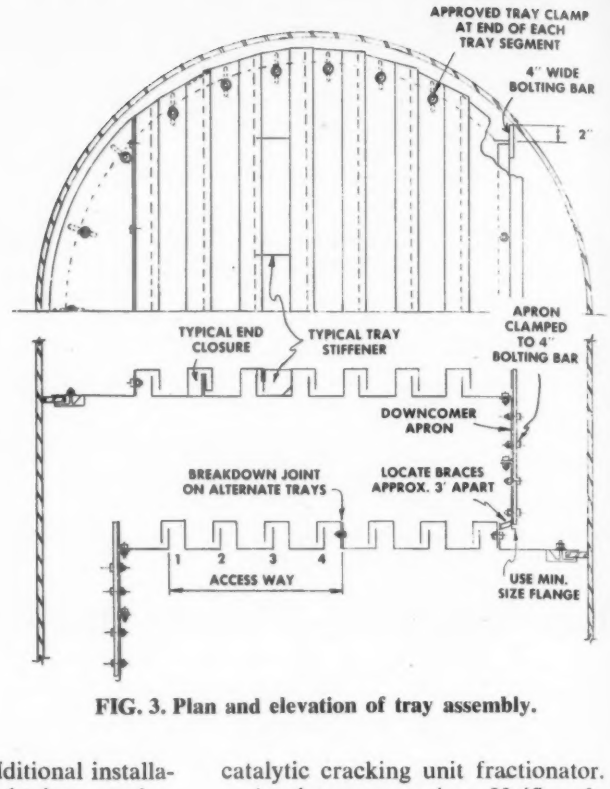

APPROVED TRAY CLAMP AT END OF EACH TRAY SEGMENT
4" WIDE BOLTING BAR
2"
TYPICAL END CLOSURE
TYPICAL TRAY STIFFENER
APRON CLAMPED TO 4" BOLTING BAR
DOWNCOMER APRON
BREAKDOWN JOINT ON ALTERNATE TRAYS
LOCATE BRACES APPROX. 3' APART
1 2 3 4
ACCESS WAY
USE MIN. SIZE FLANGE

FIG. 3. Plan and elevation of tray assembly.

light metal shops. Experience in the purchase of a large number of these trays indicates costs in the range of 60 per cent of the cost of conventional bubble cap trays of similar alloy.

The initial installation of Uniflux fractionating trays was for the catalytic cracking facilities at the refinery of Socony-Vacuum Francaise in southern France. The applications at this refinery include the feed preparation towers, the reactor effluent fractionator and its strippers, the amine absorption system, hydrocarbon absorber, debutaniezr, and a side stream stripper for recovering butane cut from the debutanizer.

This catalytic cracking unit has a capacity of approximately 22,500 bbl per day. The fractionating equipment has performed in a completely satisfactory manner from the start. Since that time numerous additional installations have been brought into service. These include such applications as catalytic polymer and catalytic gasoline depropanization, straight run gasoline stabilization, complete fractionating facilities for a 1500 bbl per stream day alkylation unit, vacuum feed preparation facilities for catalytic cracking, and continuous naphthenic acid vacuum distillation. Several installations where Uniflux trays have replaced conventional trays include 2 alkylate HF stripper columns, a coking unit fractionator, and 18-foot trays for a catalytic cracking unit fractionator.

At the present time Uniflux fractionating trays are operating in or being planned for nearly 250 fractionating tower installations in the United States and abroad, including the entire fractionating tray requirements for four complete refineries. Within a few months it is expected that a sufficient amount of reliable information will be available to assess more quantatively the performance advantages of Uniflux fractionating trays. In the meantime, Socony-Vacuum has taken the position that these trays are extraordinarily in-

FIG. 4. Downward view of a single cross-flow tray for hydrogen sulfide removal.

FIG. 5. Looking athwart a double cross-flow tray in a tower depropanizing straight-run gasoline.

expensive and that on the basis of merely equivalent performance very substantial savings in capital outlay have been realized.

The accompanying photographs show a view looking down on a 5 ft-6 in. single cross flow tray for hydrogen sulfide-amine absorption (Fig 4), and a view looking across 7 ft double cross flow trays for straight run depropanization, Fig. 5.

Consistent with Socony-Vacuum policy the Uniflux fractionating tray is being made available to the petroleum and chemical industry on the basis of a modest fee of $1 per sq ft of superficial tower area per tray. In actual practice fabricators are licensed to construct Socony Uniflux fractionating trays and this fee is included in the tray quotation by the fabricator.

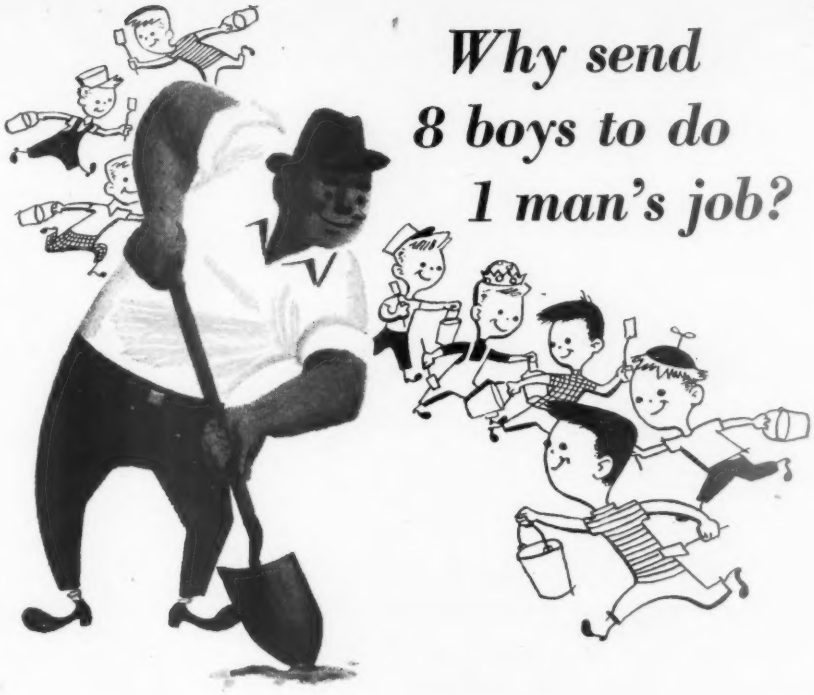
At the present time six fabricators of fractionating trays are in a position to furnish quotations in the United States and one in Europe. The information necessary for fabricators to build these trays will be made available to other firms on request.

Rating of trays will be provided by the refinery engineering division of Socony-Vacuum Oil Company, at the request of either engineer-contractors or the ultimate users. Such requests are usually processed in a matter of a few days, even though they might include all of the tray requirements for a complete processing unit, or an entire refinery. Most engineering firms and all licensed tray fabricators have been furnished copies of the Socony-Vacuum standard specification for Uniflux fractionating trays. Quotations are furnished and trays are fabricated in accordance with the aforementioned rating data and this standard specifications. * * *

AICHE of South Texas To Hold Meeting

The annual meeting of the South Texas section, American Institute of Chemical Engineers, will be held on October 22 at the Galvez Hotel, Galveston, Texas. Divided into four parts, the one day meeting will have a general session, a symposium on engine deposits, a symposium on trends in the Gulf Coast chemical industry, and a student session.

Papers to be presented will describe methods of statistical control, economics of ammonia manufacture, selection of plant sites, problems related to engine deposits and the general petrochemical outlook for the Gulf Coast. The special student session contains papers outlining current labor laws, economics, and insurance programs of interest.



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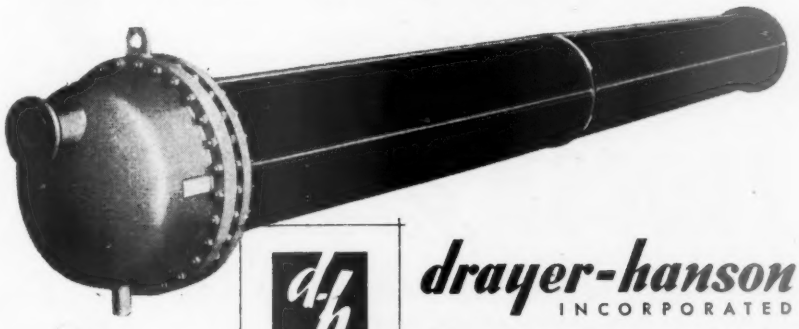

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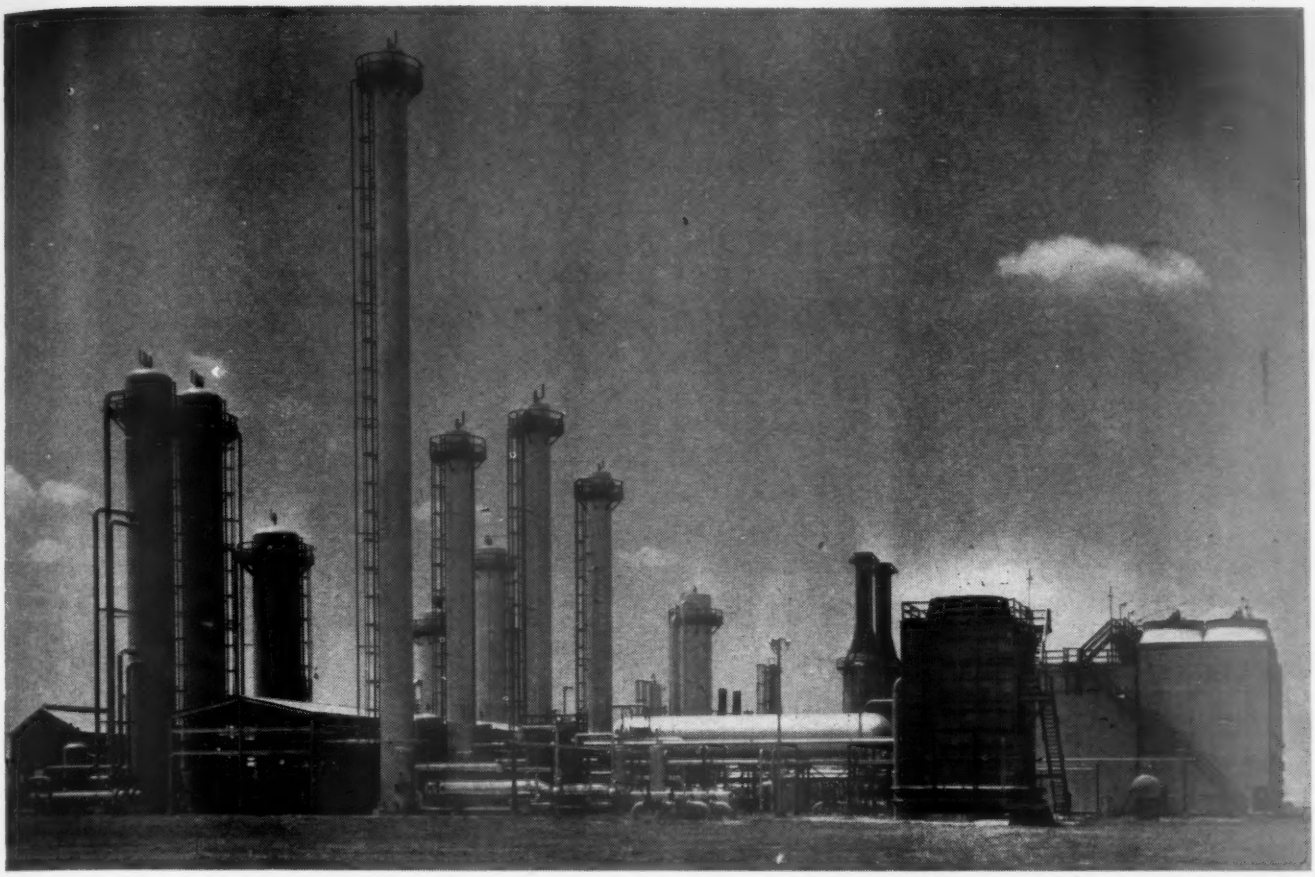


View of the Cities Service Ambrose plant, Oklahoma, one of the newest and most up-to-date gasoline plants. Note the tall deisobutanizer, superfractionator, in the foreground.

Research Blazing Trails for Natural Gasoline

Large-scale fractionation experimental developments; LPG underground storage, product purification, by-product recovery are pointing the way

ARCH L. FOSTER*

ECONOMICS-WISE, the natural gasoline chariot is hitched to two stars — the greater utilization of butane in motor and other light fuels; and the utilization of propane-butane (LPG) for purposes other than automotive fuels. On the satisfactory solution of these problems hangs the future of the industry.

As to engineering, technology and operating practices, two fields of development are showing enormous strides in recent years. These are, first, advances in fractionation that bid fair to evolutionize that ancient and not-too-well-developed art and science. The second important field is the underground storage for propane-butane, LPG, which offers a solution to the seasonal fluctuation in production and in consumption of these two very important and useful hydrocarbons.

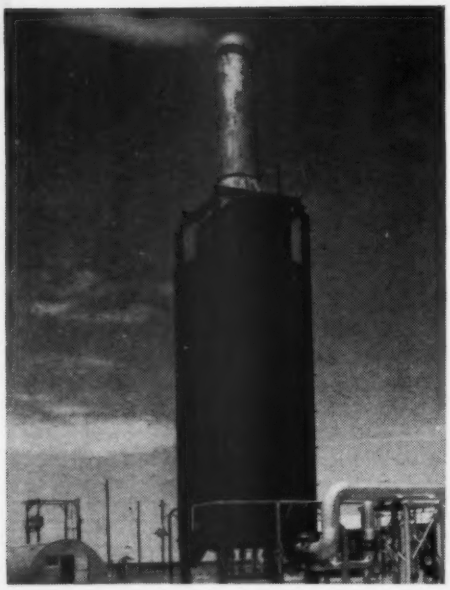
Referring to increased consumption possibilities of butane in motor fuels Legatski and Elder (NGAA, April, 1954) indicate that the industry could use 4,200,000 bbl of butane per month in summer blending, more than is now employed. If that butane is used, which means it will be produced, it will make possible a 46 per cent increase in the monthly production of natural gasoline, largely of the 26 lb Reid grade. These investigators believe that the "unsatisfied summer motor fuel outlet for butane to be at least 50 per cent greater than the figure cited" above.

Developments to date in the increase in use of light components in gasolines find that the main restriction on the use of more natural or butane is limited because of pump design, and that the adoption of pusher type fuel pumps will be hastened by use of our greater knowledge of the causes and mechanism of vapor lock. Octane rating boost by use of natural gasoline is now of the order of five numbers, if maximum use of butane is made.

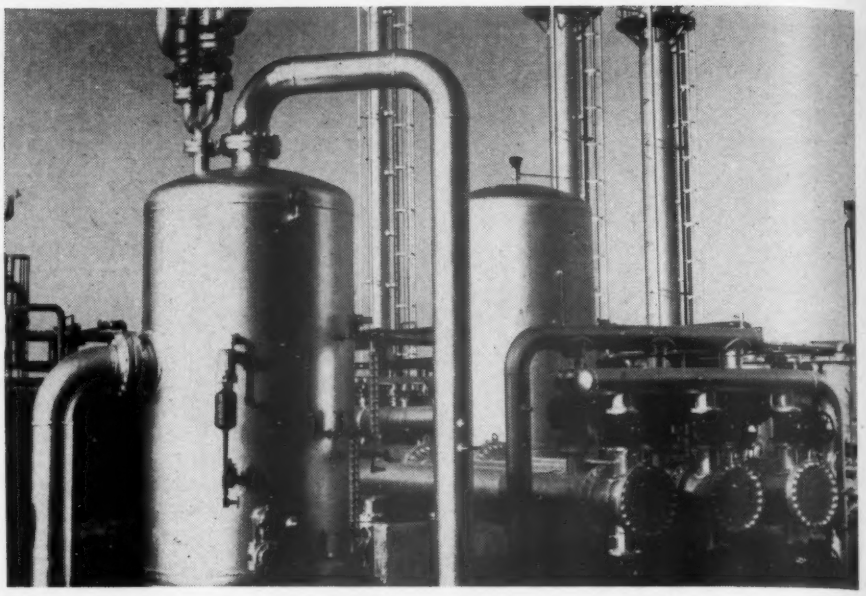
Bridgeman and Aldrich (NGAA,

*Editor, Refining, Petrochemical and Gas Processing edition.

EXCLUSIVE



Direct-fired furnaces are coming to the fore for rich oil stripping in gasoline plants, like this cylindrical heater in the Texas Panhandle.



Vessels in front are scrubbers, on incoming raw gas; in background are two absorber towers, a single reabsorber tower at left.

April, 1954), point out in discussing vapor lock that: The basic concepts necessary to a solution of the (vapor lock) problem have been available for many years, but many of these have not been expressed in usable form. These investigators "put the bee" on the automotive industry's fuel system designs by saying unequivocally that "The variations in vapor-locking tendency between different *makes* and *models* of passenger cars or even between different *vehicles* of the same *model,* are *several times greater* than the equivalent spread between fuels being marketed commercially." (Italics are ours — Ed.)

"The petroleum industry has tacitly accepted a large share of responsibility for the vapor lock problem and has been willing to exercise control on fuel vapor pressure, in order to satisfy the requirements of the average bad performers on the road." In this statement of the problem and its history these well-qualified authors indict the automotive fuel system designers frankly, with the indication that the latter should "clean house" in their designs.

Vapor lock is not a fuel problem, they say, but is traceable directly to the design and installation of these systems in the car. Methods for designating and determining "Fuel System Index" or the performance of a fuel system with various fuel characteristics are being worked out.

Much of the vapor lock problem can be eliminated by the introduction of positive displacement "pusher" type fuel pumps they say. Vapor lock tendencies of fuel system can be analyzed and characterized in terms of temperature rise, pressure drop, and vapor handling capacity and limits.

All this problem affects the natural gasoline industry probably more than any other phase of the industry, in that it affects directly the amount of natural gasoline — butane — that can be used by motor fuel manufacturers and thus controls a large portion of the natural gasoline producers' market. The more light material usable in motor fuels, the greater the market, the healthier the natural gasoline industry.

Small wonder that the industry feels this vapor lock problem, which is the problem of how much butane and heavier natural can be used in motor fuels, to be without doubt the greatest single problem faced by the industry. Operational problems shrink in significance when the ultimate market demand is a fluctuating factor.

Fractionation Research

Considering operational, process, and similar problems, the greatest advances have been made recently in two fields, fractionating equipment and methods; and underground storage for propane-butane (LPG).

That fractionation research has received strong impetus recently is not surprising. Wartime and later problems have centered around separation difficulties: Aromatic hydrocarbons are wanted in high purity for nitration stock, for aviation fuels, as petrochemical intermediates, etc.; isolation of isoparaffins and other premium components of refinery light oil streams has become a major effort in order to segregate high octane number fractions for aviation and premium motor fuel blending.

In the last few years the number of fractionator tray designs has grown to at least eight, all of which are now more or less well known to the operating fraternity. Of these the bubble cap tray is old and almost universally used. The perforated tray is an old-new idea, having been used more or less many years ago, before the bubble tray became popular, then fell into comparative disuse to be revived recently, by Celanese Corporation for fractionating complex mixtures of oxygen-containing hydrocarbon products and for other purposes.

The other five are the so-called R. E. D. tray by Socony-Vacuum engineers; the Benturi Kaskade tray by Koch Engineering men; the float-valve tray by Nutter Engineering; the recycle tray, by consultant Edw. G. Ragatz, and the Turbo-grid tray by Shell Oil experimenters. Each has certain characteristics that give it an advantage over other types; these characteristics will be discussed very briefly below.

The old standby, the bubble-cap tray is well known to the industry, and has done yeoman service in towers the world over. Yet it has faults and research is working apace to correct these as far as possible. When some riser-cap assembly does not pass vapor for any reason, liquid "dumps" down through the riser, reducing the tray's efficiency. Other problems are coning, failure to seal the caps so vapor must pass through liquid; blowing, when so much vapor passes that it "blows" the liquid aside in a mass; and pulsation, when so little vapor is passing upward that it goes through the caps intermittently. Serious research is being done on this as well as other tray designs, with a view to learning the principles involved and thus finding out how to correct the malfunctioning.

New Grease Thickener...
Estersil GT
by Du Pont

A new type of grease thickener—quite different from any previously used in commercial grease production—was recently announced by the Petroleum Chemicals Division of the Du Pont Company.

The new material, an estersil, is a pelletized form of finely divided amorphous silica with a "raincoat" chemically attached to each tiny ultimate particle.

Formerly known as PL-171 FINE SILICA, it is completely synthetic and was specially developed for grease compounding. "Built-in" water resistance and exceptional thermal stability are among its unusual and outstanding properties.

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2. Excellent Shear Stability—This new thickener enables you to make greases with exceptional shear stability under *both* normal and *high* temperature conditions.

3. Water Resistance—The chemically bonded "raincoat" means greases with unusual resistance to wash out or break down in the presence of water.

4. Superior Oxidation Stability—The need for grease antioxidants is eliminated under most service conditions because of the inertness of Estersil GT.

5. Superior Handling Qualities—Softer, more easily applied greases can be used for high temperature service because of the combined mechanical and thermal stability imparted by Estersil GT. These softer greases, of course, are more readily handled at low temperature than the more conventional types.

6. Ease of Manufacture—The completely synthetic preformed thickening structure allows reproducible grease preparation through a simple milling operation.

Du Pont will be glad to send a representative to discuss the formulation of improved greases with Estersil GT. A grease pilot plant is available to assist in this work. Samples of Estersil GT may be obtained by addressing your inquiry to Wilmington, Delaware.

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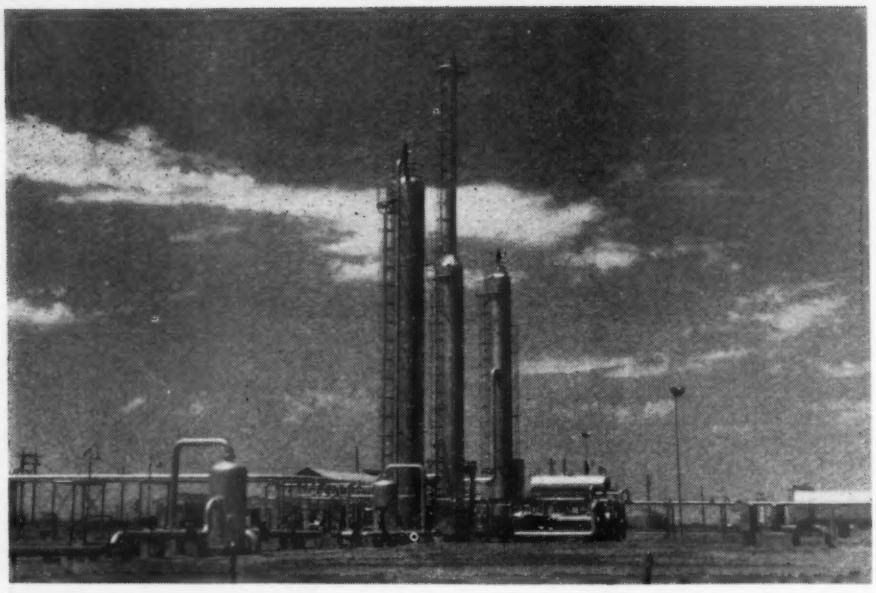


Trim and ship-shape, this Kerr-McGee Cactus, Texas plant shows systematic layout and design; note the "bottle-necked" tower in center, upper part of which is the deethanizer section.

Some of the factors in favor of perforated plates or trays is their high efficiency, low cost, fouling resistance — fouling is or may be a problem in bubble trays — and high vapor and liquid capacity. Antagonists of this tray say it must be set perfectly horizontal, be balanced too carefully and that possibilities of channelling are too great. Celanese Corporation has installed some 70-odd towers with these trays in the last 3 years, and claim to have excellent results, increasing throughput for given unit dimensions, and stating that cost of these trays is only 25 to 50 per cent of that of bubble trays.

Gulf Oil Corporation has installed their special design of perforated tray in 35 towers ranging from 2-ft, 8-in. diam to 10-ft diam, and on tray spacing of from 18 to 30 in. The Gulf tray is designed for high spacing, above 18 in., whereas the sieve type is generally built for less than 18-in. spacing. The holes are 3/32-in. diam, and on 5/32-in. to 3/16-in. centers. The sieve type may have ⅛-in. holes on 11/32-in. centers.

The Socony Uniflux tray is based on what is called an "S" member, including a trough section and a slotted vapor section. It combines the general principles of the bubble-cap design with some corrections of that design's faults, and also is more inexpensive and has been standardized by the company's engineering department. The long, inverted-trough-like vapor section extends across the tower with reinforcing support stiffeners and with each end closed. The result is a series of slotted faces or elongated "caps" open to vapor passage on only one side. Slot area is 12 to 14 per cent of the superficial tower area; rise area is 2 to 4 times that of comparable bubble tray design, thus having less pressure drop up the tower. Trays are made of 16-gauge material, weigh about 8 lb per sq ft of area, and cost about 60 per cent of similar bubble-cap trays.

The Flexitray, third design in the Koch Kaskade series, is claimed to have a very wide operating range with moderate capacity. It has liftable caps about 2 in. in diameter held down by spiders that have projections clinched underneath the tray. Caps are spaced on a triangular pitch of 3 to 6 in., as are bubble cap trays. The unit is being used in vacuum flashers, natural gasoline and petrochemical production.

The Nutter tray is characterized by a float valve, developed to give high efficiency at both high and low capacity rates. The "valve" is an L-shaped cross-section of flat metal that lies over the rise opening in the tray. Above it is a retainer sheet to hold the valve in place yet give it required space to rise. In operation the valve may lift partially to allow smaller-than-capacity amounts of vapor to pass, or it may lift entirely along its horizontal length to let the maximum amount of vapors pass. In effect this might be called a sort of "automatically adjustable" valve mechanism.

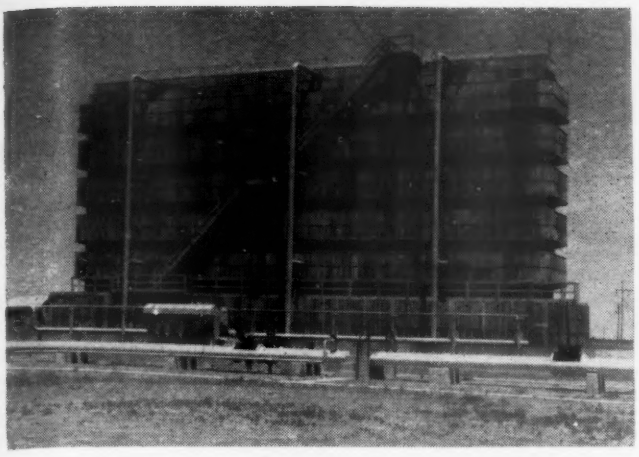
The Recycle tray includes a perforated plate on which are placed a number of recycling baffles in parallel rows across or transverse to the path of the cross-flowing liquid, with strips of free perforated plate between these rows of baffles. The baffle is an open-top box design with a series of holes tangent to the "box" bottom, and an open slot on the upstream — to the liquid — side of the box. This tray is said to have an operating range from 30 per cent to full load, as compared to 45 per cent to full load for the bubble-cap design, and to have a 45 per cent higher capacity per square foot of column cross-section than the bubble-cap. This tray is designed especially for absorbers, but is used also in fractionators; it is discussed in detail elsewhere in this issue by its inventor, "Ed" Ragatz.

The Turbogrid tray is normally designed without downcomers although such may be used. It is a flat grid of parallel slots, that can be either stamped out of the plate or may be spacing between parallel bars. These slots serve to carry both liquid and vapor to the trays below and above, respectively. This flow is intermittent, or jet in action, interference between the passage of liquid and vapor building up liquid on the tray. This tray is discussed also in detail elsewhere in this issue.

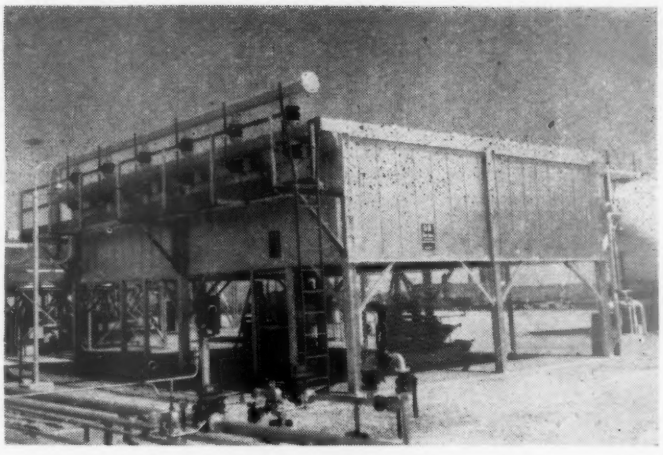
All these relatively new designs indicate quite directly the widespread and growing interest in improving fractionation, since industry and commerce both are demanding more and more efficient operations, and products in higher purity for given purposes. Crystallizing this industry-wide interest a group of 42 companies (at latest report) have combined to do non-profit cooperative work under the organization name of Fractionation Research, Inc., to determine many of the controlling principles in large-scale fractionation operations and to determine how best to attain higher efficiency, how to design to meet the requirements of high-efficiency fractionation. The purposes and progress of this organization are discussed elsewhere in this issue, but the staff has begun operation of a very carefully designed experimental tower, and expect within a five-year period to obtain the required answers to these problems of design and of operation.

Underground Storage

Among other major developments in the industry, that of providing safe, efficient, and economical storage for propane-butane by means of underground "caverns" has gone in the last three or four years "like a house afire." Four years ago the idea was chimera in the minds of visionaries, in the opinion of probably the majority of the industry's engineers and executives. The industry had always had the varying periods of over- and under-production, simultaneously with under-and over-consumption of LPG. This product can be held in aboveground tankage of a decidedly expensive sort. Nothing



Cold water or its equivalent is a must for natural gasoline recovery; this natural draft tower meets the needs of this plant that are not met by air-cooling.



This is a typical air-cooler as found in the more arid areas of the southwest, this one in Reef Fields gasoline plant.

was known about underground storage, or what caves could be used for the purpose.

Research by venturesome or desperate LPG producers led to the development of artifically built caves or cavities; water was pumped down into wells sunk for the purpose, into salt deposits and the salt leached out to create reservoirs of up to more than a million gallons capacity and then casing and tubing set and cemented in place, one line for entry of LPG, one for water to displace the LPG when returning it to the surface. Naturally the reservoir is left filled with water after leaching has reached the desired capacity, and LPG is pumped into the top of the cavern, displacing the water through a line reaching to the cavity bottom. When the LPG is wanted aboveground water is pumped into this same water line to the bottom of the cavity to displace the LPG above out through its line to aboveground temporary storage, prior to shipping.

Plants are in operation that possess six or more of these underground 'tanks,' capacity totalling several million gallons. Happily, the location of salt beds in any area where oil wells have been drilled is known perfectly from well log data and it remains largely to determine the extent and dimensions of the deposit to decide if a "tank" shall be leached out or not. The present status of this important development is discussed in considerable detail elsewhere in this issue.

Gas Dehydration

Recent development of requirements for low water content of gas delivered to transmission companies has resulted in perfection of much more highly efficient methods for dehydration. Maximum water contents of 7 lb per 1,000,000 cu ft of gas or lower values, for even a single well operator meant development of inexpensive equipment and methods to meet the economics of the situation.

Earlier such dehydrating agents as calcium chloride, alkali chlorides and bromides did not show suitable economies; more recently bauxite, silica gel, alumina, and glycols have been introduced to give more efficient methods. Each dehydrating agent has its advantages and disadvantages and these must be weighed to determine the best method or agent for a given situation.

For instance, glycol has low pressure drop, may be used where "poisons" will eliminate dry dessicants, has a wide operating capacity range; yet it may foam in operating with heavier hydrocarbons, loses efficiency with excessive water content, requires more attention from personnel, needs more maintenance, have more moving parts.

Solid dessicants cost more initially, have higher pressure drop through the unit, more rapid capacity decline with pressure decline. Gas temperatures, however, may be higher, more adaptable to semi-portable construction, can give almost completely water-free gas, are more compact units and depresses the dew point over a very wide range of temperatures. Costs for dehydration are averaged at about ¼ cent per 1000 cu ft for the average type of present-day dehydration unit.

Hydrogen Sulfide Removal

Similarly, considerable advances have been made in improving systems for removal of H_2S from raw gas, making it suitable for gasoline recovery and for line gas. Largely the ethanolamines are employed for removing sulfide and carbon dioxide to permissible limits. One company reports removal of 10,600,000 sq ft of hydrogen sulfide gas per day at a cost about $76.00 per 1,000,000 cu ft of sulfide gas removed. Corrosion appeared mainly in the reagent reactivator reboilers, in heat exchangers, and in solution pumps. Reboilers have lasted from a short 2 months to several years, in different plants.

Conclusions reached by one large operator are:

1. Have capacity large enough to permit operation with low amine concentration, 15 per cent being recommended.
2. Avoid use of dissimilar metals.
3. Provide a satisfactory amine reclaimer.
4. Consider packed and lined regenerators.
5. Avoid too high reboiler heat medium temperatures.
6. Stress-relieve major items of equipment.
7. Build for lower reactivator operating pressure.
8. Provide efficient filters and inlet scrubbers.

Commercial Uses

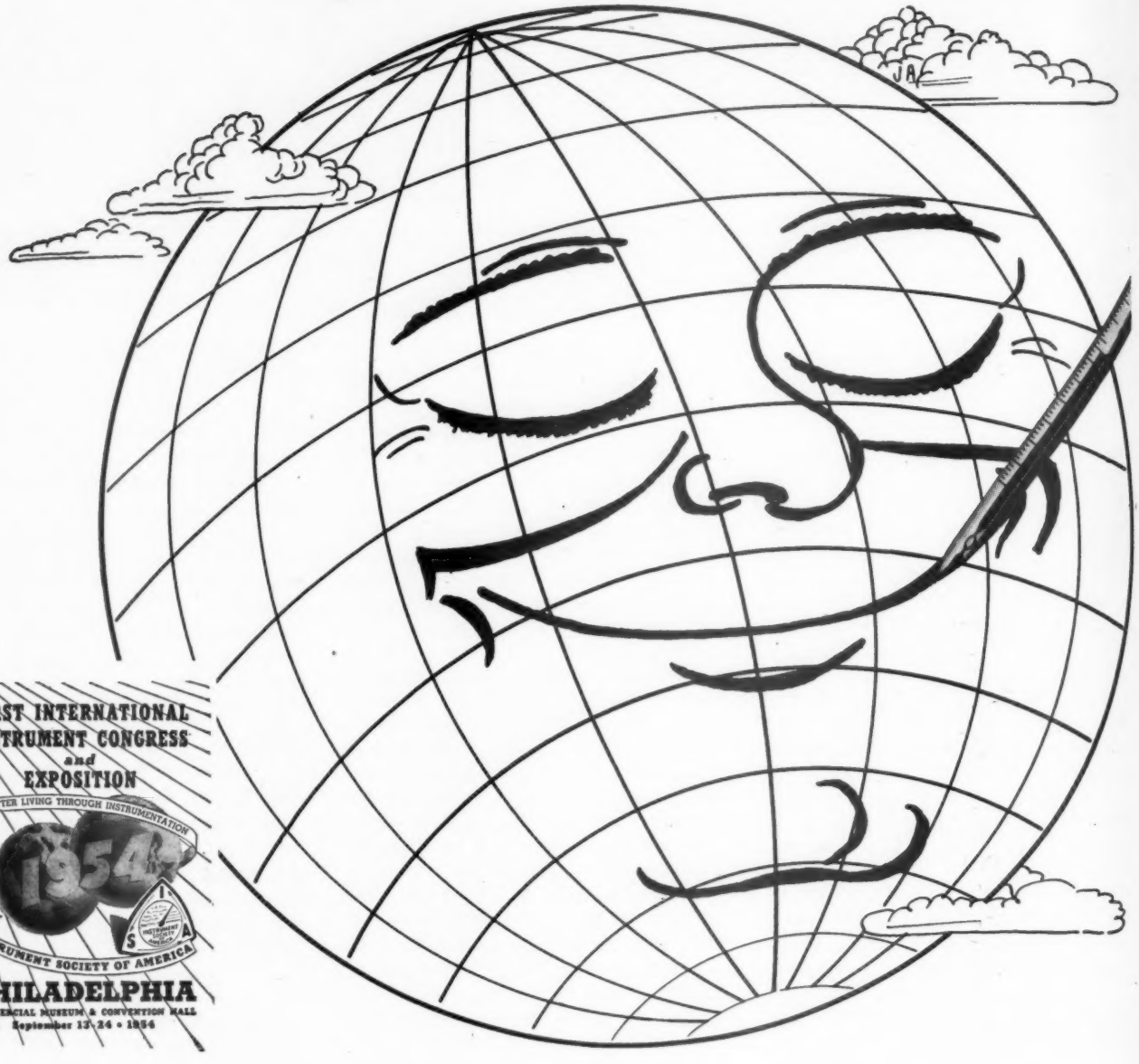
One major use of sulfide removal systems is the recovery of the sulfur as a commercial product. In some plants 10 to 30 tons sulfur recovery capacity is installed to capitalize on this "nuisance" product. Units now available to the industry make it possible and normally practicable, economically to desulfurize sour gas to pipe line specifications, with or without sulfur recovery. Needless to remark this solves one major problem for sour gas and thus increases importantly the amount of pipe line gas available to the industry and so to consumers.

Future Prospects

Prognostication is not a healthy business or pastime — for the "prophet's" reputation for farsightedness, normally. Yet it requires little business vision to indicate the trend in several phases

XUM

Taylor takes the



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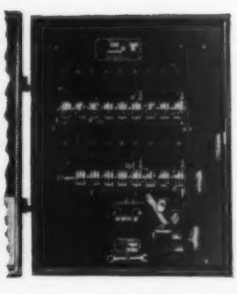


3. Automatic sequencing of batch operations. The Taylor FLEX-O-TIMER* Time Cycle Controller "does its own thinking"—takes care of as many as 36 operations automatically. Provides automatic timing of the sequence and duration of processing operations involving temperature, pressure, mechanical motion, electrical energy or combinations of each—precisely in accordance with a pre-determined schedule. Provides push-button operation for such jobs as: hydraulic press operation; batch charging and dumping; plastic molding operations; hydrogenation of edible oils and fats; dry ice molding; backwashing of catalyst and filter beds, etc.

4. Lifetime high accuracy in laboratory, routine testing. The name Taylor is your protection on etched stem thermometers and hydrometers. A.S.T.M.'s, Plain, Armored or Pocket-Type-thermometers are precision built and designed for maximum readability. Expertly annealed for minimum breakage. Specially aged before pointing and graduating for permanent accuracy. Taylor EASYKLEEN* Plain and Thermo-Hydrometers are built with the same precision. Streamlined designs assure correct readings, no trapping of bubbles on surfaces. They sink rapidly to floating point. Available with all scales recognized by the Bureau of Standards.

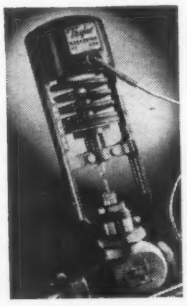
*Trade-Mark

World's Temperature -

and that's not all . . . There are Taylor instruments for indicating, recording and controlling pressure, flow, liquid level, speed, load, density and humidity as well as temperature. We can supply you with a matched set of ASTM precision thermometers, or a completely-equipped graphic panel. And throughout the U. S. A., Canada, Australia, Europe, Latin America and many other parts of the world there are Taylor trained Field Engineers to help you with your instrumentation problems. Write for the name of your local man to Taylor Instrument Companies, Rochester, N. Y.

1. Graphic Panels requiring miniature instrumentation. The rapid advances of automation in recent years have necessitated the development of the graphic panel—and consequently miniature instrumentation. Taylor was one of the first in this field and the well known TRANSET* System carries many refinements of design based on actual field experience. For example, the need for more accurate measuring devices, due to separation of the functions of measurement and/or control and indication or recording, led to the use of the force-balance principle in transmitters. Thus the small power generated by minute changes of measurement can be transmitted with high accuracy to receivers. Taylor also contributed the TRANSET Plug-In Controllers and Receivers which reduce panel size, simplify mounting, mean fewer piping connections, easier maintenance and lower labor and material costs—*at no premium to you!*

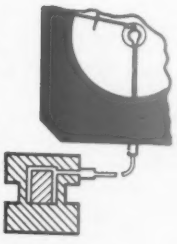
2. Complete local or point of measurement control. Fifteen years of unparalleled performance on all types of control problems have established the FULSCOPE* Controller as pre-eminent in accuracy, dependability and economy of operation. It is extremely versatile because the same control mechanisms are available for temperature, pressure, flow and liquid level—in either recording or indicating models, as locally mounted controllers, transmitters or controlling receivers. Interchangeable unit construction permits a small inventory of parts. Pre-calibrated units eliminate expensive checking. Easy accessibility means minimum down time. And the FULSCOPE Controller is adaptable to any control problem because of three control effects: Proportional Response, Automatic Reset Response, and PRE-ACT* Response (rate action) . . . another Taylor "first".



5. Dependable Non-Indicating Controllers for routine applications. The Taylor *Self-Acting Temperature Controller* (shown) is ideal for any process where air or electricity is not available and where "on the nose" control is not absolutely essential. Many ranges between 10° and 610°F. Can be used for valves up to 2"—direct or reverse acting.

The Taylor Type-P *Expansion Stem Temperature Controller* is designed for applications where "on-off" control is acceptable and where there's space for the 12" or 15" rigid expansion stem. Air operated: control point easily changed.

For simple pressure applications the Taylor *10RF Non-Indicating Controller* is available in direct or reverse-acting types. Air operated; sturdily built; inexpensive.



6. Simple, economical measurement of load or force. Taylor Volumetric Load Measuring Elements are rugged, self-contained units for measuring force *directly* on the chart or scale of a recording or indicating instrument. No auxiliary source of power is required. This is one of the simplest methods of determining tension, compression loads and combinations or both on most any type of equipment. The paper and textile industries have proved their design, accuracy and performance over many years, and recent developments have extended their utility to many other applications such as: measuring tension on conveyor belts; film tension; thrust on bearings; forces applied by pneumatic or hydraulic cylinders on squeeze rolls; weight of suspended solids or corrosive liquids in tanks, and force applied on testing apparatus.

Taylor Instruments MEAN ACCURACY FIRST

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of the industry. For one item; collaboration of more than one company in "joint" gasoline plants, serving one or more fields is expected to continue as conditions arise that make this the most economical principle on which to own and operate gasoline plants. Obviously if a producing field is large enough to support more than one large plant then two or more plants will be built. In each of these more than one company is likely to be a partner.

With the construction of our huge long-distance gas transmission lines, purification of stripped gas to meet rigid line specifications will become a stronger "must" even than at present.

With the rapidly increasing demand for light hydrocarbon products of higher and higher purity the demands on the fractionation part of the plant will become more and more exacting, to supply individual hydrocarbons, or close-cut fractions of two or three homologous compounds.

The tremendous impact of economics of motor fuel consumption of natural gasoline (butane, largely) becoming greater as time passes, the "battle" to induce or force automotive engine and fuel system designers to eliminate vapor lock tendencies from their designs will intensify, the ultimate goal being to enable the refiner to make and the consumer to use fuels for gasoline engines that contain more butane and light hydrocarbons without vapor locking.

This sword has several "cutting edges"; it will add effective octane numbers, also greater TEL susceptibility to motor fuels. By adding butane in greater amounts, these light, "clean" hydrocarbons will make for cleaner burning, more efficient fuels, that is, more horsepower per gross pound of fuel and offset possible disadvantages arising from cracked byproducts, gum, etc. It will increase our total yield of commercial motor fuel per barrel of crude, and per cubic foot of raw natural gas produced, a very sound conservation step. It will put the natural gas-gasoline industry on a sounder basis, enabling that industry to utilize more fully the maximum potential production of useful materials from the raw gas.

In addition to the use of butane for blending in regular liquid motor fuels, the use of propane, butane, and their mixtures, LPG, as separate under-pressure engine fuels, a development that is growing rapidly especially in trucks, buses and commercial vehicles offers another outlet for large amounts, in a field of very wide limits. During the entire life of the natural gasoline industry the problem of storing natural, also LPG, during slack consumption periods, to sell when consumption is at peak, and to do this economically, has not had or found a reasonable answer until underground storage was developed. To see that this practice will continue to increase indefinitely, barring the unforeseeable appearance on the scene of a disadvantage not now known, requires only a modicum of average intelligence.

Nothing has been said here about such developments as the greatly increased use of propane refrigeration in improving plant efficiency, the recovery of propane and butane thereby; about the successful fight against high pressure gas line corrosion; the development of using air-cooling to augment water-cooling especially for plants in arid, scarce water areas such as Texas, New Mexico, and Oklahoma plains country, or of the many other advances made economically, technologically and otherwise, by the industry in recent years. Yet all these things add up to the "sum" at the foot of the page of natural gas-natural gasoline- LPG progress, a most imposing total. * * *

Plant Aids

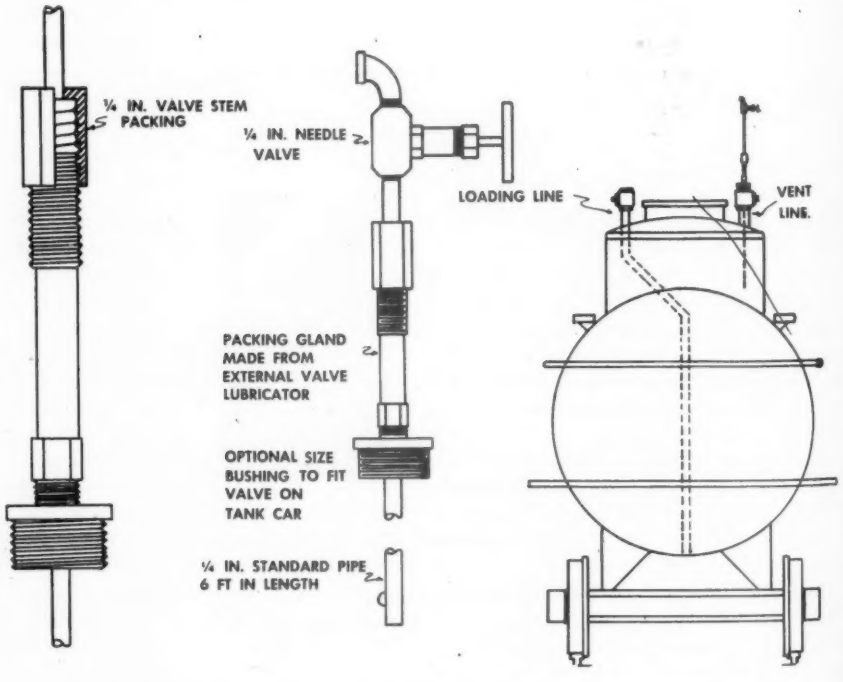
Slip-Tube Assembly[1]

W. B. NORRIS[2]

This assembly provides a safe and efficient method of sampling and loading gasoline cars. Drawings of the slip-tube assembly show an external valve lubricator, modified by drilling out the grease channel to permit a 6-ft length of ¼-in. pipe to be inserted. The plug in the grease cup of the lubricator was removed. A ¼-in. valve stem packing was then wrapped as shown about the pipe and the lubricator cup tightened to prevent leakage about the pipe. A ¼-in. valve and street ell were attached as shown and a bead weld was added to prevent the tube from slipping out of the packing gland.

The slip tube is mounted on the tank car as shown in the drawing with the proper size bushing to fit the valve on the vent line. The dome is removed to set the slip tube to the desired outage and replaced. When the car has the proper outage liquid will flow from the top of the tube. The tube is then pulled out as far as possible, the vent valve closed, and removed from the car.

[1]Class B, honorable mention, NGAA Kinks Contest.
[2]Sun Oil Company, Delhi, Louisiana.


¼ IN. VALVE STEM PACKING
¼ IN. NEEDLE VALVE
LOADING LINE
VENT LINE
PACKING GLAND MADE FROM EXTERNAL VALVE LUBRICATOR
OPTIONAL SIZE BUSHING TO FIT VALVE ON TANK CAR
¼ IN. STANDARD PIPE 6 FT IN LENGTH

Slip tube assembly.

Status and Progress of Underground Storage

Twelve million barrels of underground LPG storage in use; may eventually be applied to other products

K. V. DOUGHTY and CHARLES M. COLE, JR.

THE theory and practicability of underground storage has been known for many years. It was not until a rapidly growing LP-gas industry demanded an economical storage medium, however, that underground storage was given industry-wide acceptance. It has been only four years since underground storage of major importance was put to use in this country.

Today there are some 140 underground storage facilities in use with a total capacity of approximately 11,600,000 bbl. Expansion of many of the cavities now in use, along with another 45 projects in the planning or construction stage, will boost this capacity to more than 17,000,000 bbl. Salt cavities with a capacity of 8,400,000 bbl make up a major part of the underground storage. In addition, there are some 695,000 bbl in mined cavities and approximately 2,500,000 bbl in oil, gas, and water sands. Table 1 summarizes underground storage by states.

Because of the almost fantastic growth of the LP-gas industry with its inherent problems of low summer demand, it is anticipated that more and more of such projects will be undertaken. Of the 11,600,000 bbl of underground storage capacity now in use in the United States, 93 per cent is located in the producing areas of Texas, Louisiana, Mississippi, Oklahoma, New Mexico, and Kansas.

The choice of these locations is primarily due to the salt beds which underlie most of the western part of Texas, Oklahoma, Kansas, and eastern New Mexico and the salt domes lying along the Gulf Coast of Texas, Louisiana, and Mississippi. In these areas are large markets for LP-gas and the cavities located here have done much to conserve summer production for peak winter demands. It would appear, however, that for many LP-gas producers the underground storage program has progressed to the point where it may be more economical to construct relatively higher cost hard rock mined cavities in market areas remote from the producing points, rather than to leach salt cavities at the source of production.

The cavities in areas remote from the producing points allow the use during summer months of otherwise idle tank cars, a fact which is of no little economic consequence to the marketer. LP-gas stored in such cavities may be trucked during winter months directly to local markets in the area or reshipped in tank cars on an in-transit freight basis, which because of lesser distances to markets requires fewer tank cars and provides better service to customers.

Primary purpose of underground storage is conservation, and as conservation in this instance is the saving of products that would otherwise be wasted, one of the most important requirements for a satisfactory underground storage installation is its location with respect to the markets served. The storage should be located so that the products stored may be sold directly into the local area of the storage site or may be reshipped at little additional expense over shipments direct from the producing point. Tied in closely with the marketing aspects of the location is the need for rail service, the proximity to good roads, availability of adequate water (in the case of salt cavities), and electric power. It is also desirable that the site be on a products pipe line and navigable water.

The installation should be of sufficient size to provide economical unit construction cost and when filled supply sufficient quantities of product to fulfill the demands of a winter market. An underground cavern installation should be structurally strong and at a depth sufficient to guarantee safety,

The Authors

Doughty Cole

K. V. Doughty is manager of supply, Tuloma Gas Products Company. He graduated from the University of Oklahoma in 1944, with a BS degree in aeronautical engineering. He received a masters degree in mechanical engineering from the University in 1948, and joined Stanolind Oil and Gas Company that same year. Doughty was employed in Stanolind's LP-gas sales section until transferring to Tuloma at the time of the company's formation June 1, 1954.

C. M. Cole, Jr., is also a graduate of the University of Oklahoma, receiving a BS degree in petroleum engineering in 1942. Formerly with the producing department of Stanolind, Cole has done much work connected with underground storage methods and procedures. He also joined Tuloma at the time of the company's formation.

TABLE 1. Summary of underground storage.

State	Type cavity	Capacity, bbl: Present	Capacity, bbl: Ultimate or proposed
California	Water sand	44,000	100,000
Illinois	Mined shale	510,000	510,000
Kansas	Salt red	533,000	812,000
Louisiana	Salt dome	622,000	761,000
Michigan	Salt bed	150,000	250,000
Mississippi	Salt dome	652,000	1,029,000
Missouri	Mined limestone	25,000	25,000
New Mexico	Salt bed	460,000	679,000
New York	Salt bed	125,000	125,000
Ohio	Mined rock	0	60,000
Oklahoma	Salt bed	16,000	16,000
	Mined shale	110,000	110,000
Texas	Salt dome	2,042,000	3,329,000
	Salt bed	3,892,000	6,677,000
	Permeable formation*	2,455,000	2,544,000
	Mined shale	50,000	50,000
West Virginia	Abandoned tunnel	0	200,000
Wisconsin	Mined sandstone	0	70,000
Total		11,686,000	17,347,000

* Actual total capacity is indeterminate; volumes shown represent capacity in use.

EXCLUSIVE

but not so deep as to greatly increase construction and operating costs. It should also be an adequate distance from surface structures, property lines, and other caverns. All of these requirements, however, are actually of secondary importance. A favorable geological structure must be available and in most cases this can only be determined from an on-the-spot investigation.

There are four basic types of underground storage in use or proposed for use — salt cavities, mined cavities, closed structures or permeable formations, and abandoned mines or tunnels. For the purpose of clarity, each of these is discussed separately. Major emphasis is placed on salt and mined cavities, as it is believed these types will play the major part in future underground storage.

Salt Cavities

The formation of a cavity in either a salt bed or salt dome is essentially the same and shall be treated as one. There are three essentials necessary to the formation of a salt cavity. First, there must be a soluble salt formation; second, there must be water supply sufficient to dissolve the salt; and, third, there must be a means of disposing of the salt water. These are the bare essentials and each has its own economic limitations.

The major salt beds occur in the western part of Texas, Oklahoma, Kansas, and eastern New Mexico and in the Great Lakes region of Michigan, Ohio, Pennsylvania, and New York. Salt beds also occur in the Uintah Basin in Utah and Colorado outcropping at the surface in some areas and ranging in depths of 7000 ft in others, with an average thickness of 1500 ft. In the Texas-Oklahoma-Kansas-New Mexico area, the salt beds range in depth from 1000 to 2000 ft in thickness from 50 to 1000 ft. In the Great Lakes region, the beds range in depth from 1500 to 7000 ft and in thickness from feather edge to 400 ft. Few, if any, of the salt beds are found as a continuous pure bed of salt. More often the salt is interspersed with thin layers of shale, anhydrite, etc. These impurities usually add to the problems of forming the cavity.

Salt domes are for the most part located along the Gulf Coast of Texas, Louisiana, Mississippi, and Alabama ranging inland almost 250 miles in places. These domes vary in depth from just under the surface to very deep seated domes that lie beyond the reach of the modern drilling rig. The dome is usually made up of almost pure rock salt. Other things being equal, the salt dome is usually the best formation in which to provide underground storage.

The second essential is that of water supply. Obviously, there must be an adequate supply of water to dissolve the salt. Normally it can be assumed that 7 to 10 bbl of fresh water will be required for each barrel of salt dissolved. In some areas it would be impractical to attempt salt cavity formation because of the shortage of fresh water. The term fresh water, however, should not be held to its strictest meaning. Often times brackish water with a relatively low concentration of salt will be entirely suitable.

The third essential is a means of disposing of the salt water. The problem of salt water disposal in connection with oil producing operations has been with the industry for many years and is no less a problem today. Several methods of disposing of brine from the salt cavities similar to those used in oil producing operations have been used, each with its own merits.

Above-ground pits are probably most commonly used. These can be plain earthen pits, or they can be lined with some material such as concrete or asphalt. Plain earthen pits are the cheapest, but thorough consideration should be given to the danger of damage to adjoining property in case of seepage or dam breaks. Salt water disposal wells are also used quite extensively. Such wells are usually cheaper than lined pits, if a disposal zone with a reasonable susceptibility to water injection is available at a reasonable depth. In most cases a disposal well will minimize liability risks.

Having established the availability of the three prime essentials of cavity formation at any one location, consideration must be given to the size of the cavity. The ultimate size of the cavity will depend on several factors. Of primary importance are the actual storage needs. Naturally, these must be fulfilled, if possible.

As the principle of underground storage is to conserve the surplus product produced during the summer, the theoretical limit of capacity for a cavity would be this entire summer's surplus production. This, of course, must be tempered by the market potential in the area. Seldom, however, is the limitation of surpluses or market potential approached in one cavity. More often the capacity of a unit is controlled by structural or economic limitations. The thickness of the salt will in some cases limit the size. Excessive washing in a thin bed of salt may cause a break through in the salt and expose a permeable formation with resulting loss of stored product. The structural strength of the stratum forming the roof of the cavity may also be limiting. Incidentally, a tight bed of anhydrite makes an excellent roof for a cavity.

The shape of the cavity is also a matter that must be given thorough consideration. Control of the cavity shape is a very controversial matter and subject to much speculation. Theoretically, it should be possible to obtain one definite cavity shape by top water injection and a different cavity shape by bottom injection. In actual practice the results do not always conform to theory.

Top injection shown in Fig. 1 gives the more efficient utilization of water, however, the shape is least desirable because of the wide unsupported roof which may cause trouble from caving. When water is top injected, the fresh water tends to flatten out over the brine with very little downward diffusion. The downward flow of the fresh water is essentially a direct function of the withdrawal rate. It follows that the largest diameter will be in the area of first contact with the fresh water and that the diameter will decrease as the

ABOUT THE COMPANY

Tuloma Gas Products Company is a wholly-owned subsidiary of Standard Oil Company (Indiana). The company was formed June 1, 1954, to sell liquefied petroleum gas on a nation-wide basis.

Tuloma markets all the lighter hydrocarbons from ethanes through butanes produced by Standard refineries and Stanolind Oil and Gas Company plants. Stanolind, the principal oil-producing subsidiary of Standard, is one of the nation's five top producers of LP-gas.

Headquartered in Tulsa, Oklahoma, Tuloma is now marketing products from 31 plants located in 11 states.

Most of the personnel of the firm was transferred from Stanolind. Ray A. Carter, formerly Stanolind's sales superintendent, is president. Harry R. Thomas, who had been Stanolind's LP-gas sales superintendent, is vice president and general manager.

William R. Thorne, who was Stanolind's senior sales engineer, is manager of sales, and K. V. Doughty is manager of supply.

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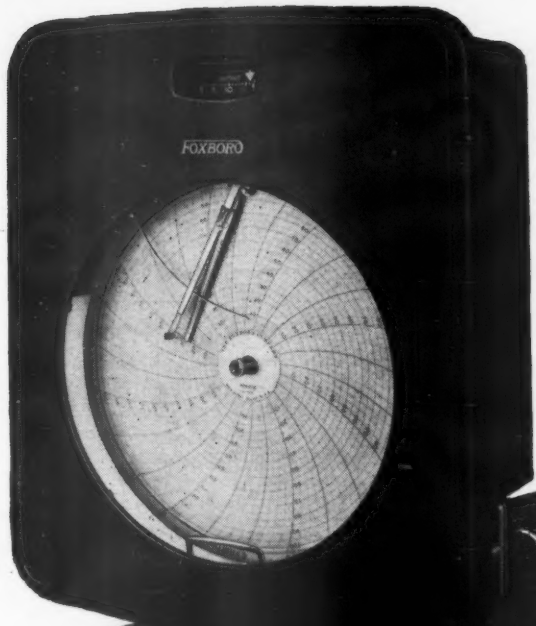

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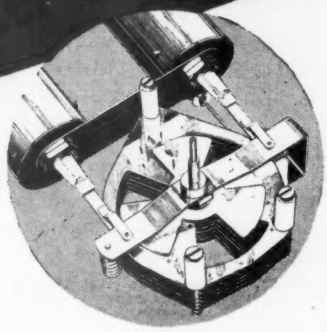

This simple variable capacitor is important to potentiometer users because it eliminates the conventional, troublesome slidewire altogether; and it gives Dynalog Instruments the continuous *stepless* balancing which assures higher accuracy, closer control.

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TOPS in simplicity . . . unequalled in its combination of accuracy, sensitivity, and speed of response . . . the Dynalog Potentiometer with standard thermocouples gives you unerring temperature measurement for any range up to 2800°F. Featuring *sustained* accuracy of ¼ of 1% of scale, it's an instrument of laboratory precision built to withstand the severest industrial conditions.

Unprecedented freedom from maintenance is the direct result of unique Dynalog design. There's no slidewire, no battery to standardize. There are no gears, belts, or high speed reversing motors. There's nothing to wear and cause dead space.

Single pen recording models provide full scale pen travel in 3 seconds standard, or as fast as 1 second without extra cost. The Multi-Record Dynalog provides color-coded records of up to 6 points at 6 second intervals. Both types give the convenience and low cost of circular charts.

Dynalog Potentiometers are also used for the measurement of pH, oxidation-reduction potential, and for other applications in which the process variable can be converted to a dc millivolt signal. They are available for pneumatic or electric control.

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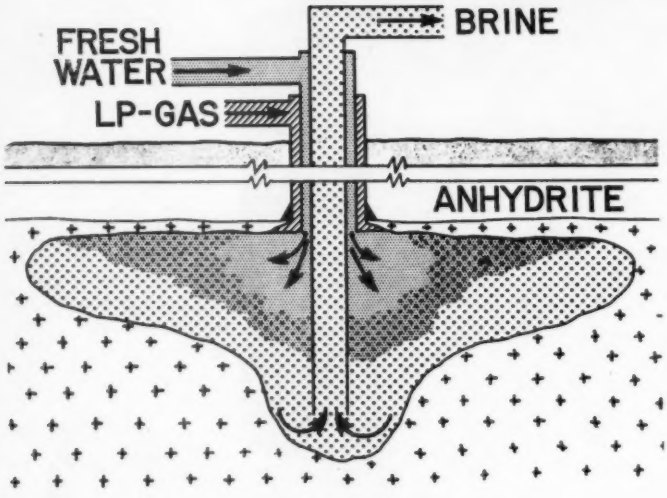


FIG. 1. Salt cavity, theoretical shape by top injection.

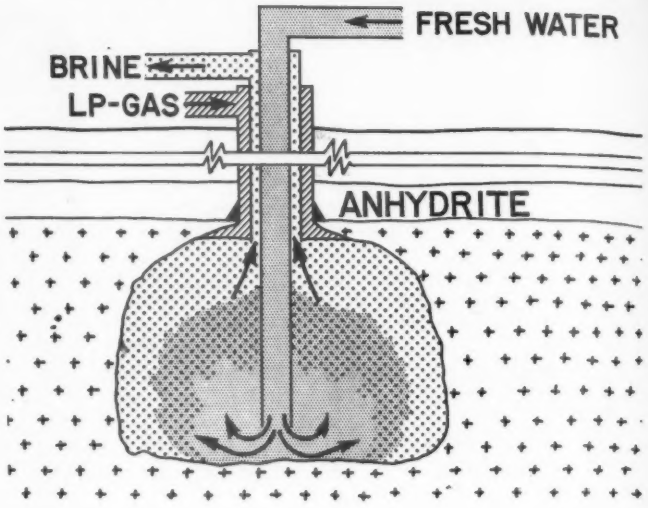


FIG. 2. Salt cavity, theoretical shape by bottom injection.

water becomes more saturated on its downward trip through the cavity.

With bottom injection, shown in Fig. 2, the fresh water tends to rise along the outside of the tubing. Salt is picked up by diffusion from the brine surrounding the rising water and not directly from the walls of the cavity. Due to the rather slow rate of horizontal diffusion those parts of the cavity wall nearest the tubing will be dissolved more rapidly, which tends to give a cylindrical shaped cavity. The top of the cavity may be either larger or smaller than the average diameter depending on which is controlling—the saturation of the brine leaving the cavity, or the amount of turbulance created at that point.

Other things over which we have no control probably have a very great effect on the shape of the cavity. The continuity of the salt stratum and the exposed thickness of the formation are probably the greatest factors affecting shape.

Certain precautions can and should be taken during washout. A blanket of the product to be stored should be maintained at the top of the cavity to protect the casing shoe and the roof of the cavity. In many cases, an intermediate string of casing can be used very effectively to protect the tubing from damage by caving of cavity walls. This intermediate casing should also permit raising and lowering the tubing without the danger of hanging the tubing on insoluble stringers, which may project from the walls of the cavity.

The first step in the formation of the cavity is to provide a well bore through which to leach out the salt. Usually casing is run to an insoluble formation just above the salt and then cemented to the surface.

The fresh water circulating pump must develop sufficient pressure to circulate water through the cavity, and must have sufficient capacity to permit a reasonable washout rate. Washout rate is a matter of economics, and can be determined only after giving thorough consideration to investment, time available for washing the cavity, and water supply. If the completion date of the cavity is of minor importance, then the size of washing facilities may be held to a minimum with a resultant savings in investment. The lower the washing rate, the more efficiently the wash water will be used, i.e., saturation of the effluent water will be higher. Water rates are usually regulated to stay in the upper range of saturation, particularly if there is a short supply of water. Wash rates in the range of 50 to 200 gal per minute are common.

After the cavity has been formed and has been hydrostatically tested, it is ready to be used as a storage facility. From here on, routine operation of the cavity is relatively simple. There must be a pump available to inject LP-gas into the cavity, and a water pump to displace LP-gas when it is desired to eject it. The water used for ejection is in some cases a matter of great importance. Where it is desired to continually enlarge the cavity, it is necessary to use fresh water for displacement. In cases where the cavity already has been washed to its safe limits, it may be dangerous to continue using fresh water. Under such conditions, it is necessary to provide a source of salt water. If aboveground pits have been used for disposal, salt water will be available. If a salt water disposal well has been used, however, it will be necessary to install a pump in the well to withdraw the salt water. Other aboveground equipment such as storage tanks, loading racks, and dehydrators will usually be found at most storage sites.

The primary purposes of aboveground storage are—to absorb surges in filling or emptying the cavity, to provide for small sales volume where it is not desired to operate major equipment, and as a means of checking or altering product quality. The amount of aboveground storage will vary from a small surge tank to a relatively large volume installation. Loading facilities will be installed to serve whatever means of transportation are available. Dehydrators of a capacity to handle the maximum loading rate should be installed. Although experience has shown that very little water is picked up by the stored product while in the cavity, dehydration facilities are necessary to remove that small amount. Recovery of LP-gas from salt cavities for the most part has been excellent. There is usually some LP-gas trapped in irregularities of the cavity at the first filling; but after these traps are filled, recoveries of 95 to 98 per cent are not uncommon.

Mined Cavities

As the name implies, mined cavities are formed by mining a cavern out of shale, limestone, granite, or some other rock formation. From the standpoint of physical aspects, there is only one essential for the construction of a mined cavity, and that is a suitable bed of rock. Various localities may present certain advantages or obstacles; however, there are few, if any, that cannot be economically surmounted if a desirable bed of rock is available. Shale, limestone, granite, or other rock formations are present in every state in the Union. Those which are ideally suited for underground storage, however, are not so plentiful.

The formation must be deep enough so that the overburden is sufficient to withstand the pressure of the stored

products. NGAA Tentative Standards for the Underground Storage of Liquefied Petroleum Gas adopted as Tentative Standards August, 1952, as amended March 12, 1954, recommend 1 ft of overburden per psig of vapor pressure of the stored product. Minimum depth is usually considered around 200 ft. As the cost of sinking the shaft is a significant part of the mining operations, the depth of the formation must not be such that will cause excessive expense.

The maximum economic depth is normally considered in the neighborhood of 400 ft. In addition to confining the depth of the formation to a very narrow range, the formation must possess numerous other characteristics favorable to storage. It must be a tight, homogeneous bed with a very low permeability. It must be structurally strong enough to maintain an unsupported roof of adequate size. It must be free of water or other impurities which would contaminate or allow the escape of stored products. It must not be affected chemically or physically by exposure to damp air during mining operations, or to the LP-gas that will be stored in it.

A formation old enough, in terms of geologic age, to have developed the strength and consistency necessary for use as a cavity, may have been subjected to orogenic stresses leading to the development of fractures that would allow the escape of stored product. A few cracks of this type could probably be sealed at a minimum expense. If fracturing is extensive, however, sealing may become a major item of expense, or even rule out successful storage.

It is now evident that a succesful storage cavern will require a formation of relatively strict specifications. For the sake of economy, it is imperative that all information available on the geology of the area be gathered and evaluated before actual digging begins. Digging a $50,000 or $75,000 shaft is a very expensive way to discover that the formation is not suitable for storage. Although State and Federal geological reports, old well logs, and mining records will be of great value in the preliminary study, the next-to-final answer must come from core drilling.

The core drill will furnish information on ground water conditions, character of the overburden, and of the formation to be mined. Core samples should be tested in the laboratory for both the desirable and undesirable characteristics. The drill hole should be pressure tested to determine if the formation will contain a pressure product. A thorough knowledge of the general geology of the area will be of valuable assistance in answering questions, concerning the lithologic character of the formations, the presence or absence of local facies changes, and the possibility of unconformities. Information of this type is necessary in order to plan a program of core drilling and to evaluate the data obtained from the cores.

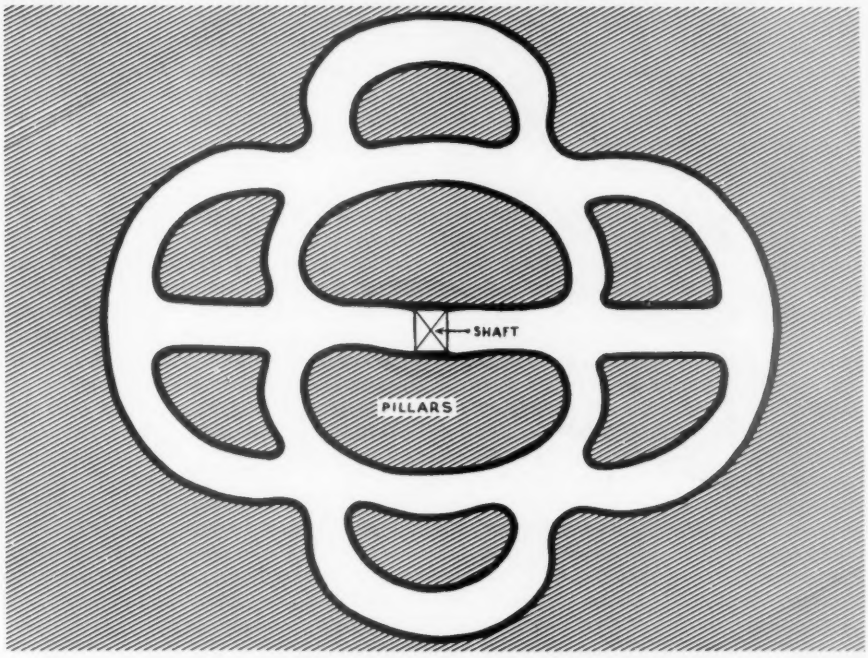


FIG. 3. Plan view of hypothetical mined storage cavity.

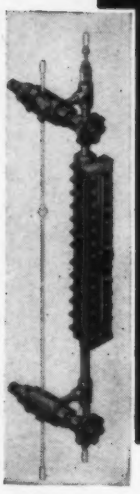
The final answer comes only after the shaft is sunk and the cavern completed and tested. Mining the cavity is usually accomplished by conventional mining methods. An access must be provided to the rock by either a vertical shaft or horizontal adit, the latter being used if the formation can be entered from the side of a hill or bluff. In view of the high cost of sinking the shaft, its horizontal dimension is usually kept to a minimum size, probably in the range of four to eight feet.

One of the greatest obstacles encountered in sinking the shaft is the interference of ground water. Large volumes of ground water can be very discouraging and expensive. Relatively small volumes can usually be handled effectively by the use of water rings. These are circular troughs installed in the shaft just below the water-bearing formation which collect the water to be pumped to the surface. Large volumes of water may sometimes be handled by grouting cement or by setting strings of casing. The main disadvantage of using casing as a seal against water is that each time a string is set, the shaft is reduced in size, thereby limiting the working area. This should emphasize the fact that complete knowledge of ground water conditions should be obtained before starting the shaft. Upon completion of the shaft, it should be cased and cemented from the roof rock to the surface.

Probably the most economically mined cavity would be one large circular room around the shaft. This is seldom possible because of the limited strength of the formation, and it becomes necessary to create tunnels leading out from the shaft. In a mined cavity, structural strength of the formation is all important because of the danger to personnel working inside the cavity. The size of the tunnels, particularly the width, depends on the strength of the rock. In a relatively weak rock, the tunnels will, of necessity, be narrow in order that the roof will be self-supporting. For a given capacity, the narrower the tunnels, the longer or deeper these tunnels must be to provide that capacity. Long tunnels will mean an increase in time and labor to remove the waste rock.

It might well be that the capacity of an individual unit may be limited for economic reasons because of the weakness of the rock formation. Fig. 3 is a plan view of a hypothetical mined cavity in a relatively weak formation. This is only one of many layouts that might be used. If the formation were stronger, the tunnels could be wider and much smaller and fewer pillars would be left for support.

A tunnel that has been sized in accordance with the strength of the formation should not normally give excessive trouble. When mining in shale,



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however, considerable sloughing of the walls and roof is often encountered. The sloughing may or may not be extensive enough to damage the cavity, but it always presents a hazard to the working crew. One of the ways to help eliminate the sloughing problem is to bolt wooden planks to the roof of the cavity. Usually, spacing the planks two to six feet apart will suffice, however, in some cases it may be necessary to completely cover the roof. It is probable that the walls of the cavity will be too jagged to install boards. A two or three-inch wire mesh will usually serve the same purpose and can be made to conform to the jagged walls. It is usually desirable to have the walls covered with wire around the shaft area where there will be a concentration of personnel. It would also be desirable to cover the walls of the sump to prevent possible damage to the pipe or pump.

For each company that has mined caverns, there will probably be a different piping arrangement. The following is offered as one of many ways a cavern can be completed, if a submerged pump is to be used to empty the cavern. A string of 8 or 10-in. casing is hung just off bottom in a sump at the lowest point in the cavern. A submerged pump on a string of 2 or 3-in. tubing is hung inside the casing from a conventional wellhead. As it will be necessary at times to pull the pump for repairs, the casing should be fitted with a foot valve which will remain open when the pump is on bottom, but will close immediately upon lifting the pump. This valve could be of a flapper or piston type. Such a valve will allow the pump to be pulled without the danger of large volumes of escaping gas.

If the vapor displacement method is used to eject LP-gas, the cavern could be completed similar to a salt cavity where water is used as the displacing agent.

Aboveground equipment such as storage tanks, loading racks and dehyration facilities would be essentially the same as for a salt cavity.

Closed Structures of Permeable Formation

Storage of this type is made possible by utilizing a formation such as an abandoned or partially depleted oil or gas formation or a water sand. Since no actual underground construction is required, it is usually the cheapest of the four types of storage under discussion. From an operating standpoint, however, it often leaves much to be desired. Although some such storage projects have been highly successful, others have been complete failures, recovering practically none of the stored product. Recovery is usually much slower than from the cavern type and products generally must be reprocessed before they are marketable. These factors are very important because peak seasonal requirements of LP-gas demands fast recovery rates.

Abandoned Mines or Tunnels

Few have been tried; fewer have been made to work. This type of storage would have the same requirements as to rock characteristics as the mined cavity. Investment cost would generally be considerably reduced, as the only actual construction would be to seal off the openings. Although its use to date has been very limited, it does offer a great potential, especially if an economical way can be found to seal fractured and broken rocks. Considerable experimental work has been done to find an economical way to seal such cavities. Some seals have been found to work in specific instances but have failed in others. An effective coating material should be inert to LP-gas and water. It should have some plasticity; it should be capable of application on moist surfaces; and, it should be inexpensive, both from the standpoint of the material itself and its application to the walls, roof and floor of a cavern.

To date practically all of the underground storage in the United States has been used for storing LP-gas. Its development for LP-gas has been prompted by the high cost of steel pressure storage and huge summer surpluses, however, such storage offers many advantages for other products. Underground storage offers the maximum in safety from fire and explosion. It offers a bomb proof method of storing fuel during periods of war. Lower costs made possible by utilizing shallow formations for storing low vapor pressure products may make storing of gasoline, fuel oil, etc., in underground caverns economically attractive.

The storage underground of anhydrous ammonia, which also has an unfavorable use ratio as compared with production, may be feasible. With increased offshore drilling activity, the salt domes in the Gulf of Mexico may be used to accumulate production from offshore wells for loading directly into tankers and barges, thus eliminating long costly underwater pipe lines and offshores storage tanks with all their problems of corrosion.

It may well be that this giant infant of four years will not only continue its phenomenal growth as storage for LP-gas, but will someday account for much of the available bulk storage capacity for many other liquid products.

* * *

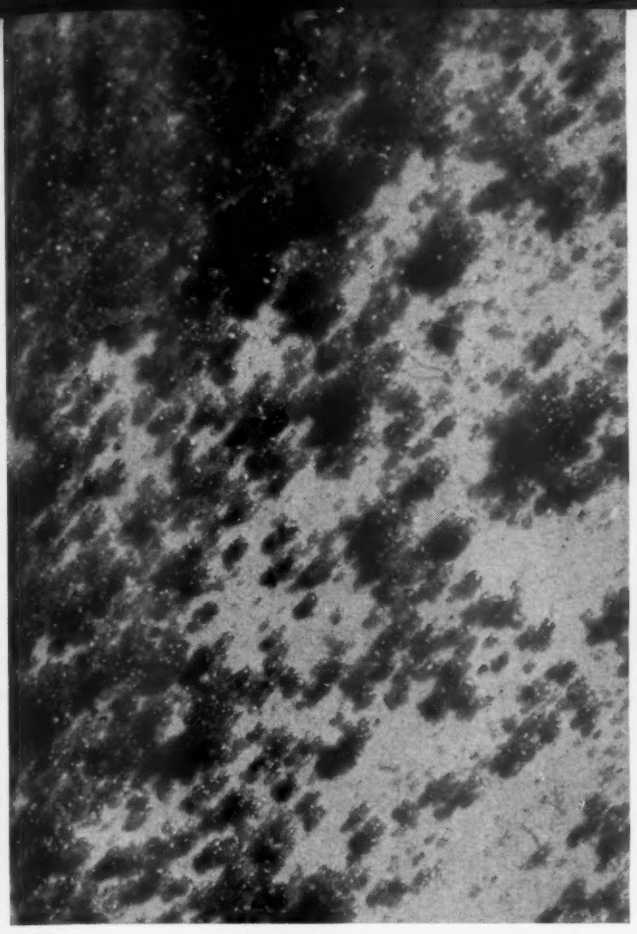

FIG. 1. Tiny specks in this photomicrograph when flowed onto the surface of a liquid form an nearly-impervious cover that reduces evaporation to a minimum.

FIG. 2. Equipment employed for mobilizing microballoons and spreading them over the surface of gasoline in a storage tank to reduce evaporation of the volatile fractions.

P 534.2

Simple Refining Equipment Used to Cut Losses

Fire-fighting foam aspirator and rotary pump used to float microballons and reduce evaporation

EUGENE B. BRIEN*

SIMPLE equipment, present in every refinery, can be used to lay a floating roof of plastic balloons atop storage tanks and thereby prevent an average of 83 per cent of the volatile fractions in the oil from evaporating. Required to float the "Microballoons" in a ½-in. thick layer are a hopper mounted on a fire-fighting foam aspirator, a temporary line, and a rotary pump powered by a 20-hp engine. Mixed with oil withdrawn from a tank via its water drawoff, the tiny phenolic spheres (0.002-0.0036 in.) filled with nitrogen are withdrawn from the hopper by a 100-psig pressure drop in the aspirator and the pump forces the mixture through the tank line into the tank.

Wetting action of the oil causes the billions of microscopic balloons to spread out evenly over the oil surface, and to adhere to one another, thus forming a virtually evaporation-proof, movable roof that floats up and down with the oil in the tank.

The phenolic plastic spheres are impervious to the corrosive action of oil and the hydrogen sulfide and salt water present in sour crudes. Performance and cost data, says the producer, show that the value of the oil saved from evaporation in one year's time is sufficient to meet original installation costs.

The 1100 lb of plastic balloons required to cover the 750 sq ft area of a 10,000-bbl crude oil storage tank can be introduced in about 40 minutes. It is estimated that losses to the industry from evaporations from storage tanks amount to about $60,000,000.

The plastic balloons were developed by the Standard Oil Company of Ohio and are produced by Bakelite Company. * * *

*Eastern Editor, The Petroleum Engineer.

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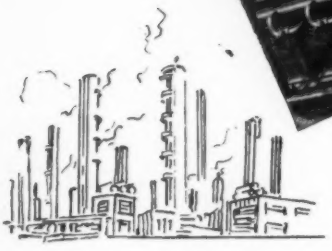

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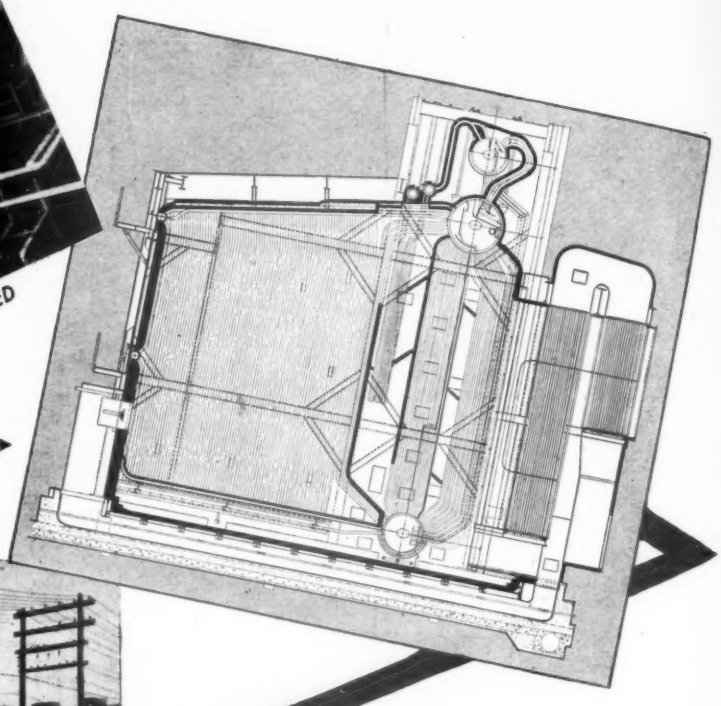
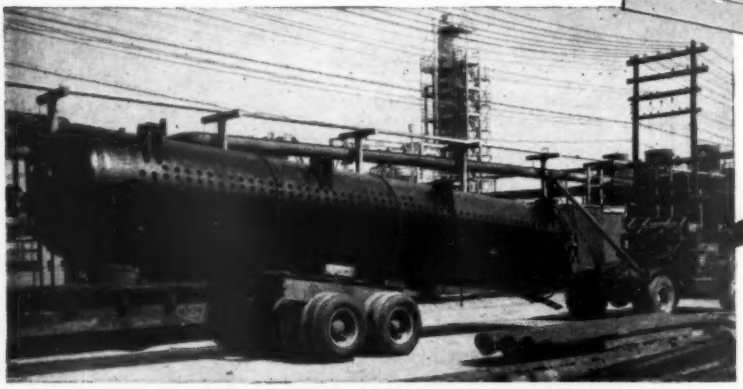
LONGITUDINAL SECTION THROUGH THE UNIT.





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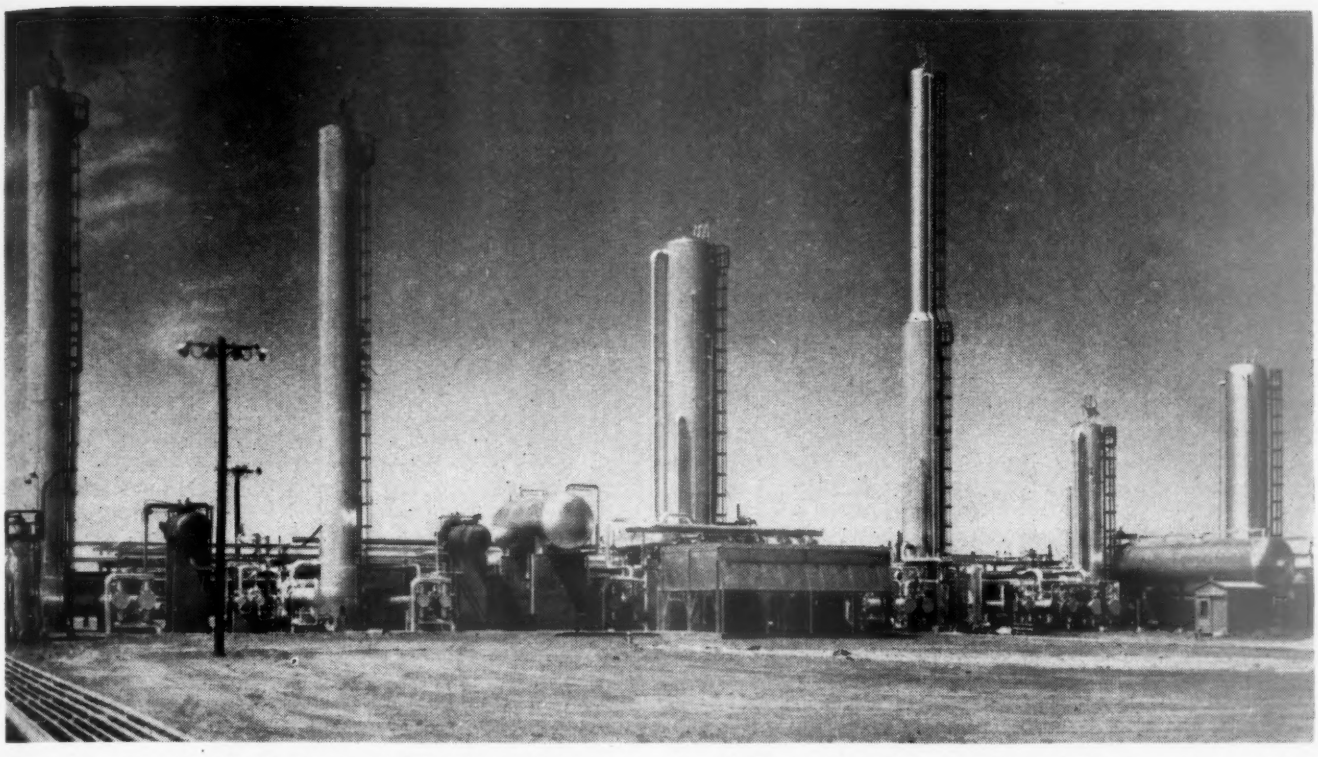


Processing area of Shell Oil Company's Elk City, Oklahoma, gasoline plant; an outstanding example of LPG processing facilities.

Liquefied Petroleum Gases for Petrochemicals*

Low cost and large available quantities make propane and butane naturals as petrochemical raw materials

H. A. MITCHELL

THE rapid growth in the production of "petrochemicals," if we may be permitted to use that term to embrace those chemicals produced from natural gas or hydrocarbons derived from the processing of natural gas or petroleum, has been one of the highlights in the phenomenal growth of the chemical industry during the post-war period. It has been estimated that approximately 25 per cent of the total production of chemicals in the United States during 1953 falls within the category of petrochemicals.

The most important group in this field both from point of view of volume of production and total value are the aliphatics, which constituted an estimated 70 per cent of the 1953 petrochemical production and are derived mainly from hydrocarbons in the range from methane through butane and the butylenes. An aliphatic can best be described as a derivative of a straight chain or branched chain hydrocarbon as contrasted to the cyclics that are derivatives of such hydrocarbons as benzene or toluene.

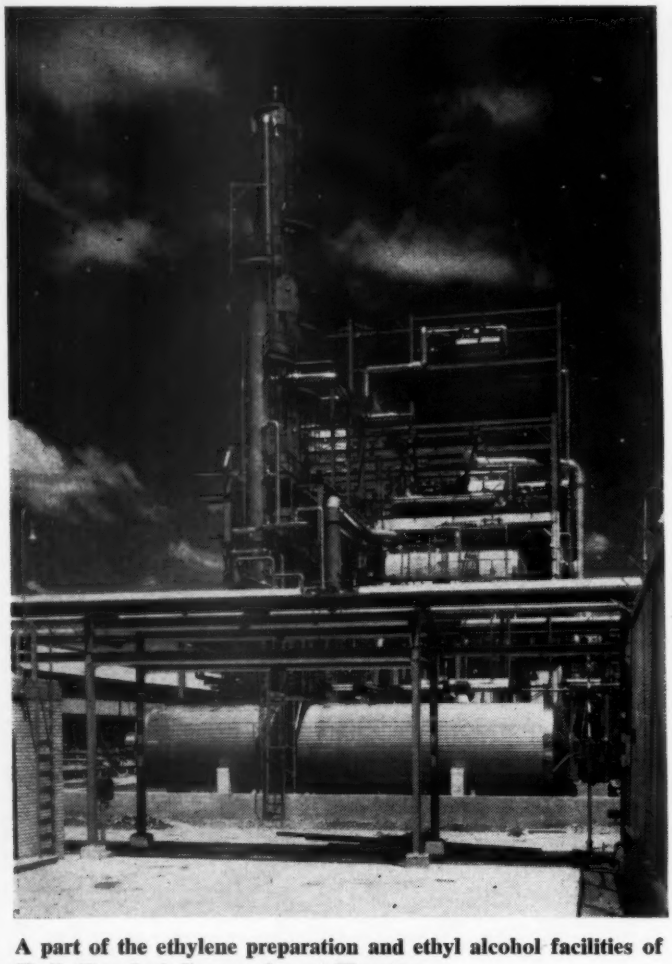
Realizing that interest in petrochemicals arises primarily from the requirements for the hydrocarbons falling within the LPG range, I shall endeavor to limit discussion to those chemicals directly or indirectly derived from hydrocarbons coming within the scope of the LPG specification. Obviously, the problem of primary interest to this group is the effect of the future growth in these chemicals upon the LPG market and the outlook for further expansion in their production.

One of the first problems to be encountered in any endeavor to evaluate LPG propane or butane requirements for petrochemical manufacture is the necessity of differentiating between the utilization of the olefinic hydrocarbons within this range, ethylene, propylene, and butylenes, and the requirements for the saturated hydrocarbons, ethane, propane, and normal butane. Regrettably, many of the statistical reports available on LPG and LRG usage do not make any differentiation between the olefins and the satuarates, and those that do frequently suffer from the broad interpretation given to LPG or LRG by the reporting companies.

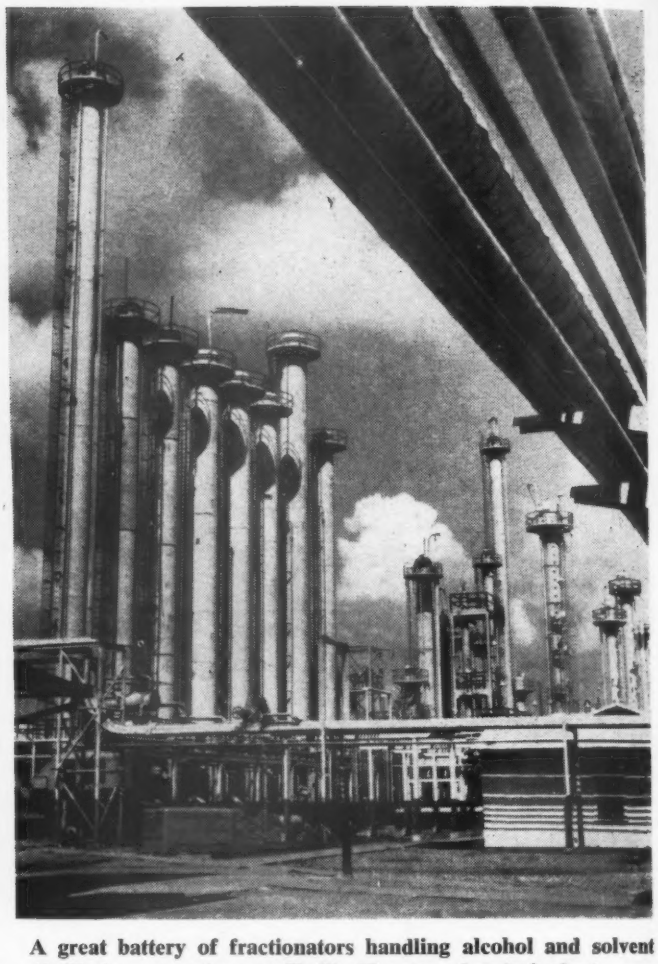
One of the most significant aspects of the post-war expansion of petrochemical production has been the growth in those chemicals derived from ethylene. The scope of chemicals directly or indirectly produced from ethylene can best be illustrated by Fig. 1.

The cracking of petroleum has long been a source of olefins for chemical

*Presented before NGAA, Dallas, Texas, April 21, 1954.



A part of the ethylene preparation and ethyl alcohol facilities of Shell Chemical Corporation at Houston.



A great battery of fractionators handling alcohol and solvent distillation operations at Shell's Houston chemical plant.

manufacture, and ethylene recovery from refinery cracking operations was the first major source of this material. As requirements increased, the cracking of selected hydrocarbon fractions for ethylene production was undertaken, followed more recently by the pyrolysis of ethane and propane in order to meet the increased requirements for this essential feedstock. This recent trend has been one of the main causes of the phenomenal increase in LPG requirements for chemical manufacture as shown in such statistical reports as the Bureau of Mines.

Synthetic ethyl alcohol is the largest single consumer of ethylene in the aliphatic chemicals, utilizing an estimated 28 per cent of the 1953 ethylene production. The petrochemical industry produced approximately 148,000,000 gal of synthetic ethyl alcohol during 1953, or roughly 60 per cent of the total United States production of this material. An estimated 50 per cent of the United States requirements of acet-

The Author

H. Allen Mitchell is with Shell Chemical Corporation and is concerned with the procurement of Shell Chemical's light hydrocarbon requirements. A graduate of the University of Southern California, Mitchell joined Shell Oil Company at its Martinez, California refinery in 1936. In 1941 he was transferred to San Francisco and helped correlate production of aviation gasoline and toluene and sove problems connected with wartime production of butadiene at government facilities at Los Angeles. Mitchell was transferred to Shell Chemical in 1946.

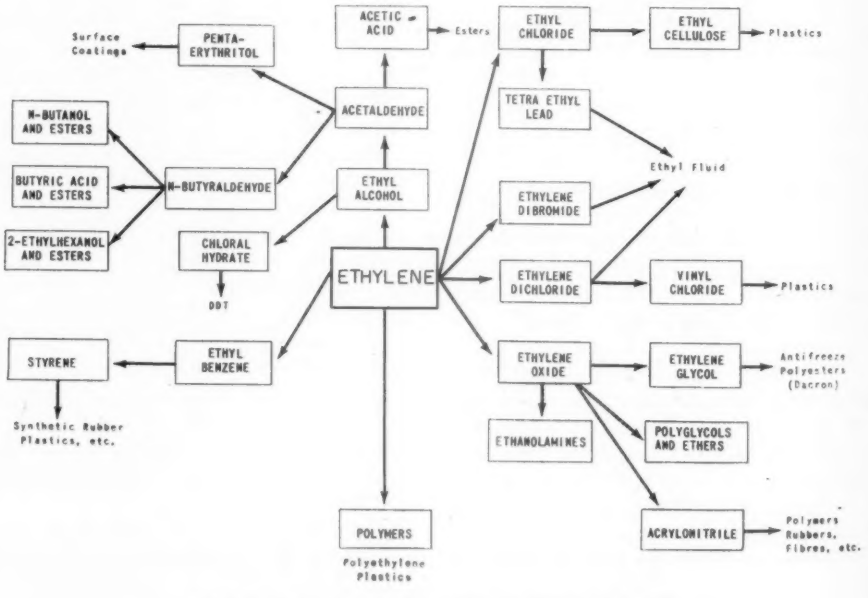


FIG. 1. Common chemical derivatives of ethylene.

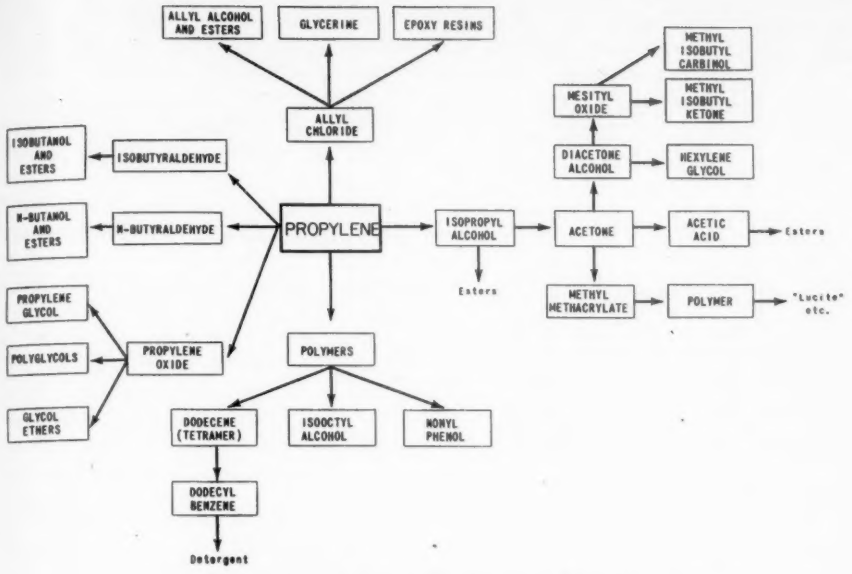


FIG. 2. Common chemical derivatives of propylene.

aldehyde and a major share of the acetic acid, acetic anhydride, normal butyl alcohol, miscellaneous acetates, and many other chemical derivatives are the end products of this large volume of primary raw material.

Next in importance, both from ethylene usage and the wide range of distribution of its derivatives, is the production of ethylene oxide and its immediate derivative, ethylene glycol. In our evaluation of ethylene oxideglycol production we are not concerned with the merits of the individual processes being utilized for its manufacture but rather must limit our attention to its position as the second largest consumer of ethylene, with an estimated 24 per cent of the 1953 ethylene production going to the manufacture of ethylene glycol alone.

A list of the derivatives of ethylene oxide and its subderivatives is, to say the least, as impressive as ethyl alcohol, and in addition to such products as ethylene glycol, which is familiar as a "permanent" type anti-freeze, and the ethanolamines, which has been encountered in gas-treating and processing operations, ethylene oxide is utilized in the manufacture of a wide group of intermediates which ultimately complete their chemical processing in the production of products covering the field all the way from the new synthetic fiber, Dacron, to plastics, detergents, and many other uses.

Other major end uses of ethylene include the manufacture of styrene, which is used extensively as a polymer or plastic in addition to its use in the production of synthetic rubber; ethyl chloride, used in the manufacture of tetraethyl lead and the production of ethyl cellulose, a new plastic development, ethylene dichloride, used chiefly in the production of TEL fluid and as an intermediate for vinyl chloride manufacture; and ethylene dibromide, a constituent of TEL fluid. One of the newest and perhaps potentially one of the largest ethylene consumers is polyethylene, a plastic of unusually versatile application already finding extensive use as an insulating material in electronic devices and, perhaps more familiar to most of you, in the packaging field where the flexible bottles are becoming increasingly popular.

As we review the fields in which ethylene derivatives are finding application, it is not surprising that the production and utilization of ethylene has grown by approximately 30 per cent during the past 4 years. Perhaps the best way to review past usage and at the same time provide a guide to estimating future requirements would be to show, as we have done in Table 1, the estimated ethylene usage for a few of the major ethylene derivatives or intermediates for the years 1950 through 1953.

I would like to qualify this table by pointing out that it represents an estimate of the ethylene requirements for the production of that portion of these chemicals produced from ethylene and thus does not take into consideration production from other feedstocks. On the basis of the growth and distribution of ethylene usage during the period 1950-1953 and taking into consideration new plants completed since that time and the anticipated increased demand for these intermediates over the next 2 or 3 years, we have estimated a total ethylene demand of approximately 3 billion pounds by 1956.

Realizing that ethylene demand is of secondary interest to you unless converted into LPG propane demand, I have endeavored to make such a conversion. In order to simplify this problem, let us look at the probable increased LPG propane requirements to produce the indicated 1 billion pounds per year of additional ethylene. After taking into consideration the increased availability from increased petroleum cracking at refineries currently supplying petrochemical plants, the new production from plants operating on ethane, such as National Petrochemicals' plant at Tuscola, Illinois, and Carbide's new plant at Seadrift, Texas, I have estimated an ethylene demand from propane cracking in the order of 500,000,000 lb per year which will require an estimated 275,000,000 gal of LPG propane (Table 1).

Lest you conclude that this increase in propane utilization will upset the present market position, let me say that propane utilization as an ethylene feed-

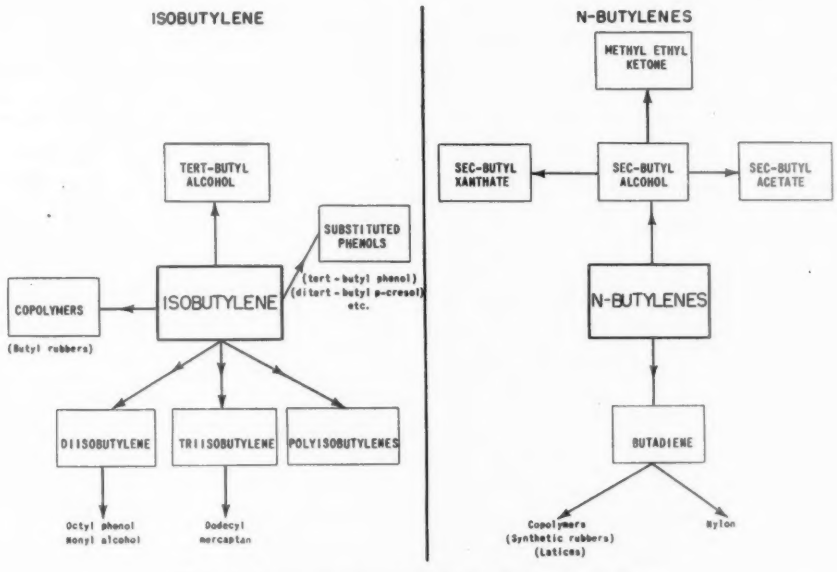


FIG. 3. Common chemical derivatives of butylenes.

Table 1. Estimated ethylene demand for major ethylene intermediates.

In Million Pounds of Ethylene Year Intermediate	1950	1951	1952	1953
Synthetic ethyl alcohol	478	557	560	603
Ethylene glycol	380	450	595	475
Ethanolamines	28	32	37	35
Acrylonitrile	25	26	28	35
Styrene	167	219	217	248
Ethyl chloride	147	175	185	197
Ethylene dichloride	95	135	135	142
Ethylene dibromide	30	35	38	40
Polyethylene	55	80	100	135
Miscellaneous	115	141	180	190
Total	1520	1850	2075	2100

stock will to a large extent be controlled by the delivered propane price. Any major increase in propane cost will divert ethylene operations to dry gas sources utilizing the more readily recoverable ethane fractions from natural gas processing facilities within economic pipe line distance of the petrochemical plants. The primary deterrent to a major expansion of ethylene operations in this direction is the limitation in availability at individual natural gasoline plants and the necessity of pipe line transportation of the ethane fraction or ethane-bearing streams.

The petrochemical operations based upon propylene, while no less diversified than those utilizing ethylene, do not have as direct a bearing upon the LPG picture. By far the largest share of the propylene utilized in petrochemical production is recovered in the course of petroleum cracking operations, and essentially all of the remaining requirements are obtained as a result of cracking operations directed primarily toward the production of other petrochemical feedstocks such as ethylene, butylene, or butadiene. For this reason it is not anticipated that the future growth in this segment of petrochemical operations will have a direct bearing on LPG demand except insofar as the increased recovery of propylene will have an effect upon propane recovery and, hence, propane availability. A brief resume of the derivatives of propylene is presented in Fig. 2 in order to round out the overall petrochemical picture.

As in the case of the ethylene derivatives, the largest single utilization of propylene is in the production of the equivalent alcohol, isopropyl alcohol, which consumed an estimated 73 per cent of the 1953 petrochemical usage of propylene. Isopropyl alcohol finds utilization in many fields such as lacquer solvent, rubbing alcohol, antifreeze, and vitamin purification as well as being utilized in the manufacture of an estimated 90 per cent of the United States production of acetone. This latter usage alone accounted for an estimated 550,000,000 lb of isopropyl alcohol utilization in 1953. Acetone, in addition to its broad usage as an industrial solvent, is the starting point for the synthesis of a diversity of alcohols, ketones, and glycols.

Second largest consumption of propylene in chemical manufacture is in the production of dodecene (tetrapropylene), which is one of the basic raw materials in the manufacture of a large group of synthetic detergents.

One of the later developments in propylene utilization is in the manufacture of allyl chloride, which is the raw material for the production of synthetic glycerine as well as being a starting point for the production of a new group of resins based upon epichlorohydrin. The remaining propylene utilization in petrochemicals includes such materials as butyraldehyde and its derivatives by the oxo process, cumene production from benzene and propylene, propylene oxide and glycol, and other derivatives. Based upon the estimated 1953 production of the propylene petrochemicals, propylene utilization in petrochemical manufacture in 1953 reached a probable level of 1,125,000 lb, or 260,000,000 gal.

Next in order but by no means least in importance in the field of chemicals utilizing hydrocarbon fractions in the LPG range are the butylene derivatives that are shown on Fig. 3. Butadiene is the most important product in this group and is used primarily in the manufacture of GR-S, currently the largest production of synthetic rubber. The 1953 production of 1, 3-butadiene from petroleum sources at the government butadiene plants totaled approximately 477,000 short tons and consumed an estimated 3,150,000 bbl of normal butane and 4,370,000 bbl of normal butylene.

Private industries' production of butadiene is primarily from non-LPG feedstocks and thus does not have any direct bearing upon LPG demand. The probable future requirements of butadiene, and, hence, normal butane and normal butylene, for the period 1955-1956 are a matter of real concern to those companies presently contemplating bidding on the purchase of those government facilities, and I feel certain that you will understand my reluctance to undertake to estimate the requirements for this period.

Isobutylene usage in the production of butyl rubber reached an estimated 840,000 bbl level during 1953 and resulted in the production of 78,500 tons of GR-I.

Aside from butadiene production, the largest usage of normal butylene in petrochemicals is in the manufacture of secondary butyl alcohol and its primary derivative, methyl ethyl ketone. Because of the limited number of companies engaged in the manufacture of these two products, detailed statistics on past production are not available from normal channels. Statistics are available, however, for the over-all production of butyl alcohols, exclusive of normal butyl alcohol, and the 1952 production of secondary butyl, tertiary butyl, and isobutyl alcohol was roughly 188,000,000 lb. As the production of isobutyl and tertiary butyl alcohol included in this total is not large, we might conclude, therefore, that normal butylene usage for secondary butyl alcohol production was in the range of 800,000 bbl (3,360,000 gal) during 1952. As previously mentioned, the production of tertiary butyl alcohol and other derivatives, including the isobutylene polymers such as the polyisobutylenes used as viscosity index improvers in the lubricating oil field, is not extensive.

In addition to the LPG usage for the production of olefins as summarized previously, there is a substantial usage of both propane and butane for petrochemical production by direct chemical methods. The best known and perhaps the largest additional factor in LPG usage for chemical manufacture is the direct oxidation process, utilizing propane and/or butane for the production of such chemicals as acetone, methanol, formaldehyde, ispropyl alcohol, normal propyl alcohol, acetaldehyde, and acetic acid to name but a few of the direct or indirect products of these reactions. Although an increase in utilization of these processes will have a bearing upon the production of the same materials by the olefinic route, the net effect upon LPG requirements will be within the limits of our estimate of increased LPG requirements over the period involved.

A small offtake of propane has developed for use in direct chlorination operations for the production of carbon tetrachloride and other chlorinated petrochemicals, but at the present time this process has had only limited application.

The increases in the production of petrochemicals during recent years and the swing to natural gas and petroleum products as raw materials for many of the new products and processes developed have been due in no small measure to the relatively lower cost of these basic raw materials and their abundance at a high degree of purity from the numerous natural gasoline producers and petroleum refiners. As we in the chemical industry look forward to continued growth in the chemical derivatives of petroleum, we feel with certainty that an adequate supply of raw materials will be available for our future needs. * * *

25 Years of Progress in Gas Purification

Application of amine solutions to remove carbon dioxide and hydrogen

NORMAN C. UPDEGRAFF and ROBERT M. REED

TWENTY five years ago, in 1929, the first Girbotol amine gas purification unit was placed in operation in Thatcher, Colorado. The process had been developed by R. R. Bottoms of The Girdler Corporation as a solution to a problem encountered by a subsidiary, The Helium Company, which had a gas supply containing 8 per cent helium and 15 per cent carbon dioxide. The removal of this carbon dioxide was a necessary step in the isolation of pure helium, due to freeze-ups in the low temperature equipment used, and the usual means of that time, caustic washing, was not economical when removing relative large quantity of carbon dioxide in the gas.

Bottoms had been experimenting for some time with various amines for carbon dioxide removal. He had discovered that carbon dioxide would react with certain amines to form carbamates or carbonates which could be decomposed on heating. None of the amines commercially available prior to 1928, however, were entirely satisfactory for use in a cyclic regenerative process. In 1928 triethanolamine became available and proving satisfactory in laboratory tests it was placed in commercial operation for the first time the following year.

In 1930 the first plant was placed in operation on natural gas for removing hydrogen sufide and slowly the process began to spread industrially. In 1938 sixteen Girbotol units were reported in operation, the Thatcher plant having been shut down by that time. In 1942 the total had climbed to 102 plants.

Today there are several hundred Girbotol units in operation. Carbon dioxide removal units range in size from small inert gas purifiers to large ammonia synthesis gas operations. Carbon dioxide is also recovered from flue gases and kilns for use in making dry ice and liquid carbon dioxide. Hydrogen sulfide removal units are in universal use on refinery and natural gas applications many of them supplying hydrogen sulfide to sulfur recovery units for the production of elementary sulfur. Of the several processes that have been used for this purpose, this process is the only one to reach such a wide degree of acceptance in so many fields. Many units originally employing competing processes have since been converted to this process.

The Authors

R. M. Reed

N. C. Updegraff

Dr. Robert M. Reed is technical director of The Girdler Company, gas processes division. Reed attended the University of Washington where he obtained his BS in 1929, MS in 1930, and PhD in 1935. From 1930-1937 he was employed by the Procter and Gamble Company, chemical division, as a research and development chemist. From 1937 to 1938 Reed was engaged in the manufacture of aromatic chemicals at Swann and Company, Birmingham, Alabama. Since 1938 Reed has worked for Girdler successively as chemist, chief process engineer, chief chemical engineer, and technical director. During this period, he has been engaged in process development, design and operation in the fields of acid gas removal by amine scrubbing, hydrogen production, the manufacture of liquid and solid carbon dioxide, and gas dehydration.

Norman C. Updegraff is assistant technical director of the gas processes division. He was graduated from Harvard in 1940 with an AB degree in engineering sciences. After a short period of development work with General Foods he joined du Pont in 1942 where he worked as a production supervisor in neoprene manufacture. He joined Girdler in 1946 and has been specializing in process design of plants for the production, purification and use of various industrial gases. He is coauthor with R. M. Reed of the "Carbon Dioxide" and "Hydrogen" sections of the Encyclopedia of Chemical Technology, and has published a number of miscellaneous papers on the production and purification of various industrial gases and the recovery of elemental sulfur.

Chemistry of the Process

The Girbotol process is based on the reactions of acid gases, H_2S and CO_2, with certain amines which are organic bases, as follows:

$$RNH_2 + H_2S = RNH_3HS$$

$$RNH_2 + CO_2 + H_2O = RNH_3HCO_3$$

(Where R represents an organic radical)

These reactions are reversible and the equilibrium proceeds to the right or left, depending on the temperature, and on the partial pressure of the acid gases. The absorption temperature is generally 80 to 120 F and pressure ranging from atmospheric to well over 1000 psig have been employed. By raising the temperature of the amine solutions to their boiling points, the reactions proceed to the left and the acid gas is expelled.

As was mentioned above, the first Girbotol process plants employed an aqueous solution of triethanolamine as the reagent. This later was replaced with monoethanolamine in order to obtain more complete removal of H_2S from the gas than was obtainable with triethanolamine in ordinary absorbers. Monoethanolamine is a much stronger base than triethanolamine; the dissociation constant of monoethanolamine is 5×10^{-5} at 20 C as compared to 6×10^{-6} for diethanolamine and 3×10^{-7} for triethanolamine, and consequently will absorb acid gases more readily than triethanolamine.

In purifying refinery gas it has been

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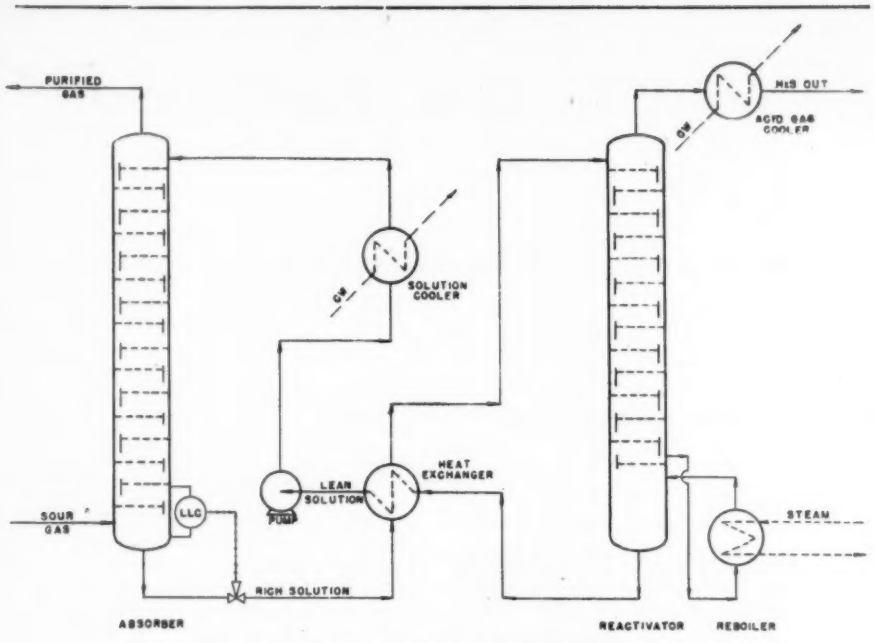

FIG. 1. Basic flow diagram of Girbotol Process.

found desirable to use diethanolamine due to the carbonyl sulfide, COS, generally present in such gases. If monoethanolamine is used the carbonyl sulfide will react with it to form a urea derivative that is not broken down in the reactivator. Thus, in a short time the ethanolamine is fixed, its alkalinity gone, and desulfurization stops. Carbonyl sulfide does not react with diethanolamine and passes on through the absorber.

Triethanolamine is still used in some cases in which carbon dioxide and hydrogen sulfide are both present and it is desired to remove the H_2S but not the carbon dioxide. By the proper choice of operating conditions it is possible to attain a certain degree of selectivity in this respect.

The amines are generally employed in aqueous solutions varying from 15 to 30 per cent by weight of amine. The flow rate of solution required is determined by the quantity, composition, temperature, and pressure of the gas to be treated as well as the characteristics of the solution selected and the degree of purification desired. Therefore, each case must be studied separately in order to design the most economical unit for the purpose.

Basic Cycle

The flow diagram of a typical Girbotol gas purifying plant is shown in Fig. 1. It may be seen that this is a continuous process in which the solution passes through the absorber where the acid gas is removed from the gas, through a heat exchanger and into the reactivator. In the reactivator hydrogen sulfide and/or carbon dioxide is stripped from the rich solution by heat and passes out of the tower as a concentrated gas together with some steam into the acid gas cooler. The steam is condensed in this cooler and returned to the cycle.

The reboiler shown at the bottom of the reactivator supplies the heat necessary for the process. Although steam is shown on this diagram, other sources of heat are being used successfully such as hot oil and direct firing of oil or gas. High pressure steam is frequently employed in larger installations for driving the solution pumps with the exhaust steam being utilized in the reboiler.

The lean solution, essentially free from acid gases, passes from the bottom of the reactivator through the other side of the heat exchanger, a circulating pump, a solution cooler, and back to the absorber. The positions of the solution pump or pumps will vary in individual cases depending on the pressure of the treated gases. The case shown is typical for high pressure natural gas operation. If the gas pressure is not sufficient to return the solution to the reactivator, an additional pump is required for the rich solution.

These plants are customarily designed to purify gases at their full line pressure and the pressure drop through the equipment ordinarily will not exceed 5 to 10 lb per sq in. In treating natural or refinery gases, if the gas mixture is at its hydrocarbon dewpoint, the treating temperature should be maintained 10 to 20 F above the inlet gas tempertaure to prevent the condensation of hydrocarbons in the treating equipment. The same effect may be achieved by lowering the gas pressure, but this is usually undesirable in natural gas operations.

Another type of process is in use for purifying liquid hydrocarbons in a similar manner. A packed or sieve plate tower is used for the absorber and either the liquid hydrocarbon or the amine solution maintained in a continuous phase depending on the specific case. Slight additional instrumentation on the absorber is required for this application but the balance of the plant is identical to that shown for gas treating. Hydrogen sulfide may thus be removed from natural gasoline as effectively as from natural gas.

Although solution heat exchange equipment has been widely used in Girbotol process plants to effect heat economies, analytical studies of the operating conditions in absorbers and reactivators have shown that under certain conditions optimum heat recovery can be obtained between rich solution and acid gases rather than between rich and lean solutions, so that a preheating section may be used in the reactivator to replace conventional solution heat exchange equipment. In cases where this type of operation is applicable, an appreciable saving in equipment cost may be effected with little increase in utility requirements.

Split Flow Cycle

In order to obtain more efficient use of stripping steam, the basic flow scheme has been modified in two plants to the "split flow" shown in Fig. 2.

A portion of the rich solution from the absorber flows to the top of the reactivator, passing part-way down it in countercurrent flow to stripping steam (generated by boiling solution in the reboiler), and then flows back through heat exchangers and coolers to a mid-point of the absorber. This semi-lean solution can absorb much hydrogen sulfide, but contains enough as it enters the absorber so that it cannot remove all the hydrogen sulfide from the gas. The balance of the rich solution from the absorber flows to the mid-point of the reactivator, down to the base of the tower, and through the reboiler, being completely stripped of hydrogen sulfide. This lean solution flows through heat exchangers and coolers to the top of the absorber, and effects complete removal of the residual hydrogen sulfide from the gas stream. Both solution streams flow to the base of the absorber.

Desulfurization, Dehydration

When it is desired to dehydrate gas streams to avoid hydrate formation in pipe lines, it is possible to combine this operation with desulfurization by employing a combination solution of diethylene glycol and ethanolamines.

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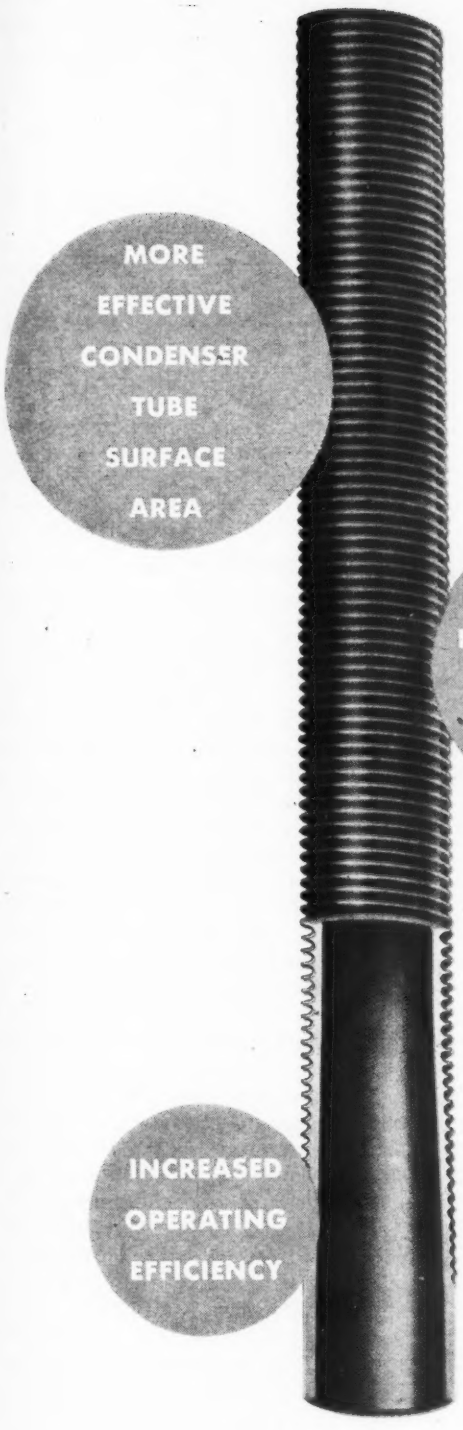

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In the course of early investigations of such amine-glycol solutions, it was noted that the mixture dehydrated gas more completely than diethylene glycol alone with the same water content. This was attributed to the hydration of the amine. The hygroscopic nature of the ethanolamines themselves apparently was not fully appreciated at that time. It now is known that monoethanolamine is considerably more hygroscopic than diethylene glycol, while diethanolamine is about equal to diethylene glycol in hygroscopicity.

The Girdler Corporation installed a process plant in 1939 which employed an 85 per cent solution of diethanolamine to effect simultaneous desulfurization and dehydration of natural gas. The dehydration effected was equal to that obtained with diethylene glycol, and in addition hydrogen sulfide removal was obtained. The relatively high viscosity of the concentrated diethanolamine solution limited its effectiveness somewhat, and in later plants a solution containing monoethanolamine, diethanolamine diethylene glycol, and water has been utilized for the simultaneous dehydration and desufurization of natural gas. The viscosity of this solution is only about one-fourth that of the concentrated diethanolamine solution, so that it can be processed in heat exchange equipment more effectively than the more viscous solution.

Although considerable publicity has been given to the use of amine-glycol mixtures for the simultaneous desulfurization and dehydration of natural gas, these mixtures are not usually employed for the treatment of gases containing appreciable quantities of H_2S and Co_2. It is general practice to dehydrate such gases separately with diethylene glycol or bauxite after purification has been accomplished with an aqueous amine solution.

Problems and Solutions

As can be expected with any process that has come into general use, a number of operating problems have arisen in connection with different process plants. The solution to these and similar problems has led to many improvements in plant design and operating techniques. The following are typical of the problems that have been encountered.

(1) Solution carryover and foaming.
(2) Fouling of solutions by sludge.
(3) Thiosulfate accumulation in solutions.
(4) Accumulation of organic acids in solutions.
(5) Corrosion of equipment.
(6) Decomposition of solutions.
(7) Losses of amines by vaporization.
(8) Incomplete purification.

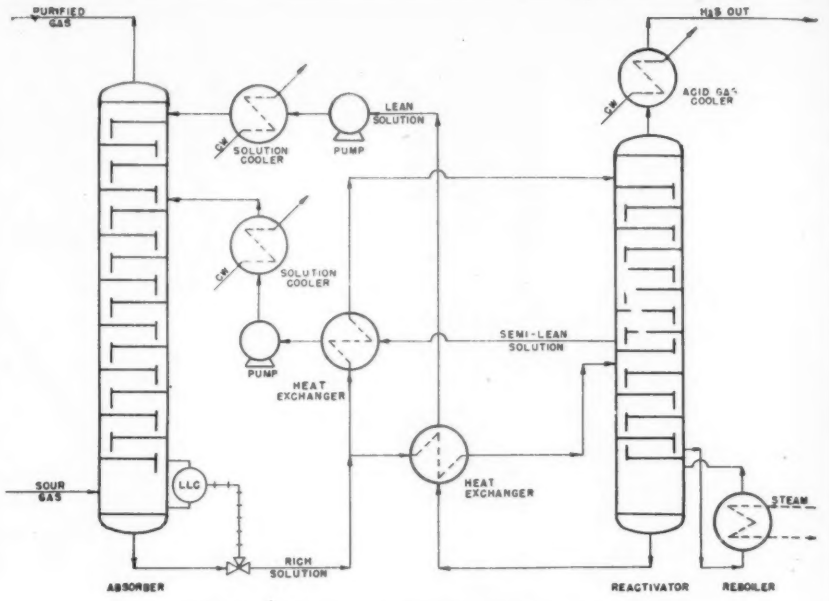

FIG. 2. Flow diagram of split flow Girbotol process.

Solution carryover from the tops of absorber towers has occurred in several plants. In common with other alkaline solutions, amine solutions will react with organic acids to form salts, many of which have soap-like properties, and will cause the solutions to foam when present in them. Organic acids are present at times in natural and refinery gases, and in such cases will promote foaming in amine solutions. This foaming may seriously decrease the gas handling capacity of the absorber.

Fortunately, however, it has been found that the addition of small quantities of suitable anti-foaming agents to the amine solutions will overcome the foaming tendency of the solutions.

In one case, in an absorber in a plant purifying natural gas with aqueous monoethanolamine solution, solution carried overhead at a gas rate of only 14,000,000 cu ft per day. After about 15 parts per 1,000,000 or oleyl alcohol (ocenol) were added to the solution, the gas rate was increased to 50,000,000 cu ft per day with no carryover occurring.

Sludge accumulations in amine solutions have proved troublesome at times. The sludge, ordinarily consisting of iron sulfide and sulfur, is carried into the absorber as a dust with the gas stream. Microscopic examination of sludge taken from an amine solution has shown it to be identical with material present in core samples taken from the gas producing formation. As iron sulfide is not readily wetted by hydrocarbons, the dust does not settle out of the gas stream in condensate separators, but is carried on into the absorber, where the amine solution scrubs it out of the gas. Iron sulfide sludge will also be present in amine solutions in cases in which corrosion of pipe lines and equipment is occurring with the formation of iron sulfide.

Although the sludge accumulation occurs at a rate of only a few pounds per day, it frequently becomes troublesome in natural gas purification plants unless steps are taken to remove it from the system. When present in sufficient quantity, iron sulfide sludge may foul heat exchanger surfaces, erode metallic surfaces at points of high solution velocity and plug bubble tray and packed towers.

Various methods have been used for overcoming sludge problems, such as the installation of filters to separate sludge from the amine solution, the periodic cleaning of equipment with water and with inhibited hydrochloric acid, and the use of water scrubbers on the gas stream before it enters the absorber. Centrifuges also have been used very successfully for cleaning the solutions, and in some cases solutions have been freed of sludge by decantation.

Another source of contamination of the amine solutions has been in the formation of thiosulfate. This occurs when solutions containing sulfides are contacted with oxygen, present either in the gas stream or by exposure of the solutions to air. The most common case in which thiosulfate accumulation ocurs in the amine solution is in plants in which gas collected in vacuum gathering systems is being purified. This gas will frequently contain as much as 0.5 per cent oxygen, present due to air leakage into the system.

Oxygen is also sometimes present in

some refinery gases resulting from catalytic cracking operations. When both hydrogen sulfide and oxygen contact an alkaline solution, such as a sodium carbonate or an amine solution, oxidation of the sulfide occurs, resulting in the formation of thiosulfate.

Thiosulfates are relatively stable salts, and amine thiosulfate does not dissociate on heating like amine sulfide or carbonate, so that the presence of amine thiosulfate in the solution decreases its effective amine concentration by a corresponding amount. By adding caustic soda or soda ash to an amine solution containing amine thiosulfate, sodium thiosulfate will be formed and the combined amine will be liberated. In this way the effective amine concentration of the solution may be maintained, until the solution becomes saturated with sodium thiosulfate.

It will then become necessary to separate sodium thiosulfate from the amine solution. This may be done either by steam distillation, stripping the amine out of the solution, or by extraction, separating the amine from the solution by a solvent in which the sodium thiosulfate is insoluble. The operation can be carried out either batchwise to reclaim a complete charge of solution at one time, or it may be carried out as a continuous operation on a small side stream of the amine solution.

In addition to the traces of organic acids present in gas streams that sometimes cause foaming in amine solutions, there have been a few cases, particularly with refinery gases, in which the gas streams contained sufficient quantities of organic acids (principally formic and acetic acids) so that a fairly rapid accumulation of these acids ocurred in the amine solutions. In such cases, a treatment similar to that used with thiosulfate may be employed, namely to add soda to the solution until the sodium salts become concentrated, and then recover the amine from the solution either by steam distillation or by extraction.

Corrosion of equipment has been a serious problem in some plants, while in other such plants little difficulty has been experienced. These plants normally are built entirely of iron and steel, since amine solutions, like ammonia, will dissolve copper and brass and most alloys containing zinc or copper. Aluminum has been utilized to some extent, although it is susceptible to attack in the presence of iron sulfide.

Absorbers usually are free from corrosion difficulties, although at least two cases have been reported in which corrosion cracks appeared near welds in absorber shells and piping after about two years of service. This was apparently due to stress corrosion. Numerous other absorbers, however, have given satisfactory service for long periods of time, and no particular difficulty is anticipated in avoiding a recurrence of this type of corrosion.

Rich solution piping and control valves occasionally are subject to corrosion, particularly in cases in which corrosion also occurs due to the abrasive action of iron sulfide sludge in the solution. Control valves are normally trimmed with stainless steel, but carbon steel pipe generally has a satisfactory service life. Heat exchangers should be provided with suitable impingement baffles to prevent erosion. Corrosion of carbon steel exchanger tubes on the rich solution side has occurred at times, but the frequency of occurrence of such corrosion has not been great enough to warrant the general use of alloy tubes in solution heat exchangers.

Reactivators have been subject to corrosion in a few plants. In one plant corrosion occurred to such an extent that the reactivator was replaced after five years' service, and in another plant the reactivator shell was protected by an outer lining after three years' service. In both of these plants the natural gas being purified contains more CO_2 and H_2S, and it is felt that the corrosion has been accelerated by the presence of the CO_2. These plants both circulate aqueous monoethanolamine solutions. The use of Gunite concrete linings plus the use of stoneware packing has proved successful in overcoming corrosion problems with reactivators.

In another plant heat exchanger and reactivator corrosion occurred at a relatively high rate with a circulating solution that was a glycol-amine solution being utilized for concurrent H_2S removal and dehydration of natural gas, also containing more CO_2 than H_2S. In this case, the corrosion was stopped entirely by replacing the glycol-amine solution with an aqueous amine solution. This change was made after laboratory studies showed the aqueous amine solution to be less corrosive than the glycol-amine solution.

Operating results with the aqueous amine solution verified the laboratory findings. Dehydration of the gas is now being effected with a separate dehydrating solution. No corrosion has been reported in reactivators above the solution inlet or in the outlet pipe to the H_2S cooler even though the concentrations of H_2S and CO_2 are high. H_2S coolers have not corroded to any extent except in cases in which iron sulfide sludge has accumulated on the tubes, or water (saturated with H_2S and CO_2) has lain in contact with them.

Reboilers have corroded in the same plants in which severe reactivator corrosion has occurred, but in most plants no serious difficulty has been encountered. Substantially no corrosion has been experienced in solution pumps, except for the abrasive effect of iron sulfide. No corrosion difficulties have been encountered in the solution coolers.

In two plants corrosion occurred due to the accumulation of hydrogen cyanide and ammonia in the system. These components were present in the gas stream being treated and were absorbed along with the hydrogen sulfide and carbon dioxide. In the reactivator these materials were desorbed but the condensate from the acid gas cooler soon became saturated with ammonia. As a result a corrosive condition was set up due to the co-existence of hydrogen cyanide and ammonia in the acid gas cooler. When this was recognized the problem was solved by discarding the reflux from this cooler and using condensate from the reboiler as makeup to the system.

In addition to corrosion on the process side, as described above, there have been other cases of corrosion reported due to corrosive steam or cooling water, which corroded the carbon steel tubes of the equipment it has been used in. The process corrosion experienced in H_2S removal plants has ordinarily not been associated with decomposition of the amine solutions, but has appeared to be due to specific conditions of temperature and concentrations of H_2S, CO_2 and amine occurring in certain parts of the equipment.

As a result of efforts to overcome corrosion in this type of plant, it has been found that some remedial measures are available. For example, use of corrosion resistant materials and changing operating conditions to avoid corrosion have given reasonable freedom from corrosion in several cases.

Decomposition of amine solutions has occurred in a few cases. For example, the monoethanolamine in one plant solution was completely converted to diethanolurea by reaction with carbonyl sulfide present in traces in the gas being purified. In another case monoethanolamine was converted into N-ethanolacetamide by reaction with ketene. Neither of these compounds is alkaline, and neither is convertible back to monoethanolamine on boiling in an aqueous solution. This problem can be overcome, however, either by utilizing amines which do not react with such compounds, or by installing suitable equipment for regenerating the amine from these compounds.

There has been no evidence thus far to indicate any thermal decomposition of monoethanolamine in aqueous solu-

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tions, even at temperatures as high as 300 F. Thermal decomposition has been noted in few cases with glycol-amine solutions, presumably due to localized overheating. Although no evidence of thermal decomposition has been noted with aqueous monoethanolamine solutions, one case has been reported in which severe reboiler corrosion resulted from the use of high temperature oil as a heating medium, with resulting high metal skin temperatures. In two instances, organic compounds isolated from aqueous monoethanolamine solutions have indicated that at temperatures near 300 F monoethanolamine and carbon dioxide will react to some extent to form diethanolurea.

Losses of amine by vaporization into the gas stream have not been a serious problem in Girbotol process plant operation, since the amines are relatively non-volatile, and the small quantity of amine that does vaporize can be readily recovered by a simple water washing section in the top of the absorber. A similar water washing operation is also carried out in the reactivator to prevent amine being lost with the acid gases leaving the plant.

Incomplete purification has been a problem only in plants in which other operating difficulies have been encountered, such as solution foaming or carryover, or in plants in which the necessary provisions have not been made for obtaining sufficient contact between gas and solution in the absorber, or between solution and stripping steam in the reactivator.

Process Applications

As has been indicated above, the Girbotol process has been widely received by industry for problems involving removal of hydrogen sulfide from various industrial gases. Probably the greatest use of the process is in the purification of natural gas. In the early days it was customary to flare sour natural gas at the well head but increased demand for gas as well as conservation measures have made this practice undesirable. Thus, gathering systems have been installed and central desulfurization units installed. In some cases the hydrogen sulfide contents of the gas has reached as high as 50 per cent.

In order to purify the gas for pipe line transportation it is generally necessary to reduce the H_2S content to something less than 5 grains per 100 cu ft of gas. In most cases the gas must pass the U. S. Bureau of Standards lead acetate purity test (less than 0.25 grains per 100 cu ft) to be acceptable to the pipe line companies. This is readily accomplished, and operating conditions for 3 large size natural gas purification units are shown in Table 1.

TABLE 1. Performance data on Girbotol plants.

1. McKamie Gas Cleaning Company, McKamie, Arkansas	
Gas flow	
High pressure gas (1434 psig)	42,700,000 scfd
Low pressure gas (360 psig)	7,290,000 scfd
Acid gas content inlet gas	
High pressure gas	H_2S 5.8 per cent, CO_2 4.5 per cent
Low pressure gas	H_2S 10.0 per cent, CO_2 4.2 per cent
H_2S content outlet gas	
Both streams negative to lead acetate test.	
2. Texas Gulf Sulphur Company, Worland, Wyoming	
Gas flow	30,000,000 scfd
Pressure	300 psig
H_2S content inlet gas	34 per cent (vol)
H_2S content outlet gas	Neg. to lead acetate
3. Stanolind Oil and Gas Company, Slaughter field, Texas	
Gas flow	60,000,000 scfd
Gas pressure	174 psig
Total acid gas inlet gas	7.5—8.8 per cent
H_2S content	1.4—1.5 per cent
CO_2 content	Balance
H_2S content outlet gas	Neg. to lead acetate

In many cases the quantities of gas treated are quite large and the hydrogen sulfide disposal problem becomes critical. An economical solution to this problem has been found in the use of a sulfur recovery unit in which the hydrogen sulfide gas discharged from the unit is converted to elemental sulfur. In such cases it is generally desirable to employ aqueous solutions of ethanolamines since glycol-amine solutions will absorb an appreciable quantity of hydrocarbons as well as hydrogen sulfide. These hydrocarbons form carbon in the sulfur recovery plant which deposits in the equipment eventually requiring a shutdown for its removal.

Due to the increased use of sour crude oils in refinery operation many refinery gas streams have an appreciable hydrogen sulfide content that must be removed prior to further processing. In other cases liquid streams of lighter hydrocarbons such as propane and butane often must be desulfurized. In addition to these refinery streams the use of catalytic reforming processes requires the removal of sulfur from the recycle streams to avoid poisoning the expensive catalysts used.

As related above, the first commercial application for the Girbotol process was a carbon dioxide removal problem. In more recent years this phase of operation has become more and more important. A large number of small units are used in the removal of carbon dioxide from gas streams produced by inert gas generators for metallurgical and other processes. Somewhat larger units are used for removing carbon dioxide from raw hydrogen gases produced by the steam hydrocarbon process.

In many cases involving the production of high purity hydrogen, 3 stages of carbon monoxide conversion to carbon dioxide are employed, each followed by a carbon dioxide removal step. It is customary in such plants to operate the 3 carbon dioxide absorbers in series with the solution first contacting the gas of highest purity. After passing through the 3 absorbers the amine solution is regenerated and recycled in the usual way. Carbon dioxide contents of product hydrogen can thus be reduced to less than .001 per cent by volume.

Of increasing importance recently has been the removal of carbon dioxide from ammonia synthesis gas. In many plants this process has replaced the water scrubbers previously used. Advantages of using this process are found in that removal may be carried out prior to compression of the gas, little or no synthesis gas is absorbed along with the carbon dioxide as is the case when using water scrubbing, and the by-product carbon dioxide is of sufficiently high purity that it may be used for the production of dry ice or urea.

In the field of dry ice production this method has proved very satisfactory and has replaced older processes such as the use of sodium and potassium carbonates in many cases. In many installations the carbon dioxide is recovered from flue gases generated for that purpose. In such plants an economical energy balance can be attained by generating steam with the fuel being burned. The steam is first used as a source of power for the compression equipment required with the exhaust steam from these drivers being used for the heat required in the reboiler. In addition to the use of this process for large scale carbon dioxide plants, it is used in a large number of portable carbon dioxide generating units that have been supplied to the armed forces and others.

Perhaps one of the more unique uses is that of removing carbon dioxide from the atmosphere of the new atomic powered submarines, the Nautilus and the Sea Wolf. By removing the carbon dioxde as fast as it is generated by the breathing of the crew it is possible to stay submerged for long periods of time without danger or discomfort to the men.

Economics of Process

It is not possible to present any satisfactory cost information on the use of this process as the treating conditions are subject to so much variation. Plant investment costs will vary appreciably with site, volume and composition of gas treated, treating conditions, desired purity, and type of plant. Operating costs will also vary considerably depending on a number of conditions. Costs have been reported in the past for desulfurizing natural gas which ranged from 3 mills to 2 cents per 1000 cu ft but these are not necessarily the

extremes in either case.

Any cost data must be related first to the purpose of the installation. In natural gas purification the cost of making the gas suitable for pipe line transportation may be offset considerably by the credit that may be obtained from recovering hydrogen sulfide as elementary sulfur. In the purification of ammonia synthesis gas, the cost per ton of ammonia produced is the only significant figure. Similarly, in the production of hydrogen or dry ice, it is the relation with the sales value of the product that counts rather than the cost per 1000 cu ft of gas treated.

In general, it can be said that in most cases the benefits to be gained by separating acid gases from the various streams far outweigh the costs of building and operating the unit. Each case, however, must be evaluated individually.

Summary

In closing we can say that the Girbotol process in its 25th year is still making progress. Its use in its original applications continues to spread and at present no other process can compete with it for economy or efficiency. In addition new applications for the process are still being uncovered and its future apears to be sound.

The several hundred plants which have been built since 1929 for employment of the gas treating and liquid treating processes have brought out other modifications and improvements than those discused above and have provided the engineers of The Girdler Company with a wealth of practical design information. The present dominant position of these absorption processes in their respective fields is due in no small measure to the operating experience which has been accumulated through the years. * * *

SHALE OIL SYMPOSIUM

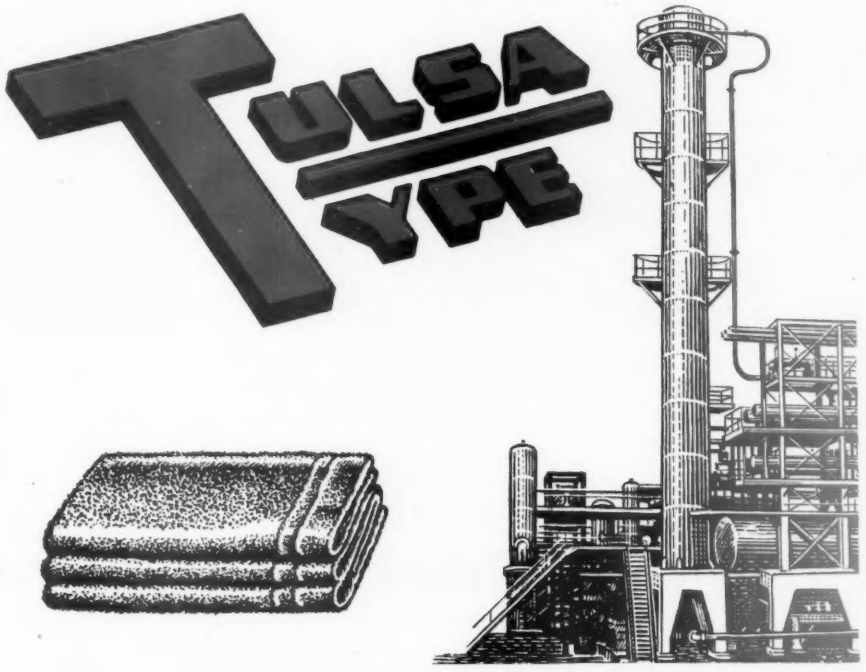
Five papers of the first magnitude will be presented on Oil Shale and Shale Oil Processing, at the National Meeting of the American Institute of Chemical Engineers in Glenwood Springs, Colorado, on September 13 forenoon, Hotel Colorado. The subjects are "Advancements in Fuels Production from Oil Shale," by Clyde Berg, Union Oil Company; "Thermal Extraction of Oil Shale Kerogen," by W. R. Thompson, C. H. Prien, Denver Research Institute; "Thermal Processing and Chemical Treating of Colorado Oil Shale," Boyd Morris and R. J. Cameron, U. S. Bureau of Mines; "Catalytic Cracking of Shale Oil Coke Distillates," C. K. Viland, Tide Water Associated Oil Company; and "Recycle Hydrogenation of Shale Oil Crudes," by R. L. Crecelius and others, U. S. Bureau of Mines.

The convention extends from September 12 to 16 at the Hotel Colorado.

This symposium should be the most important assembly of data yet offered by any technical group on the subject of oil shale and its recovery and utilization. Union Oil Company has developed a retort for recovering shale oil that offers interesting possibilities; two of the papers are by Bureau of Mines technologists, associated with the major project carried on at Rifle. Denver University and also Tide Water Associated have carried out important investigations on shale oil.

OMITTED

Credit for "Trends in Modern Instrumentation," by Glen H. Gallagher, The Fluor Corporation, Ltd., which was published in the Reference Annual for July 1954 should have been given the California Natural Gasoline Association, where the paper was presented at the annual fall meeting, October, 1953. We regret we did not give proper credit at the time the article was published.



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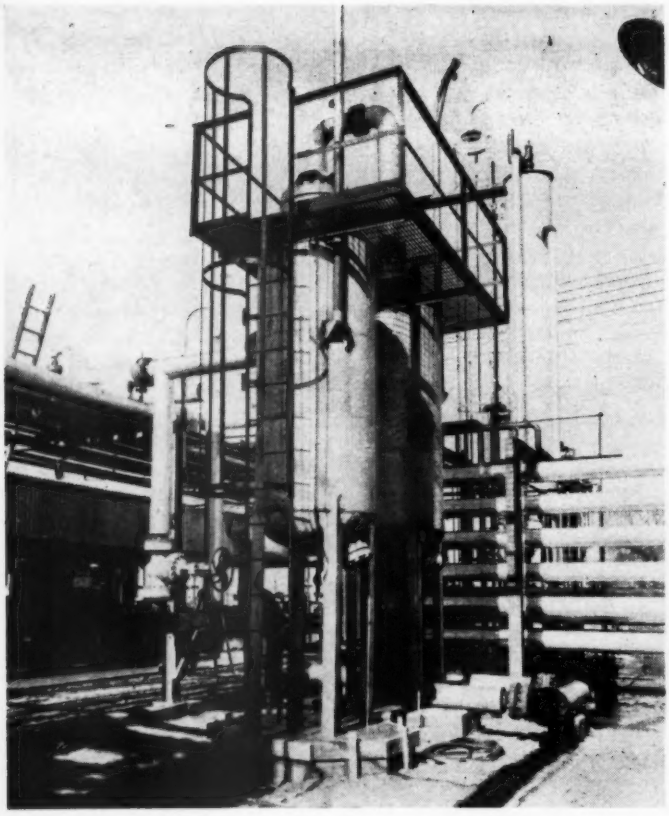
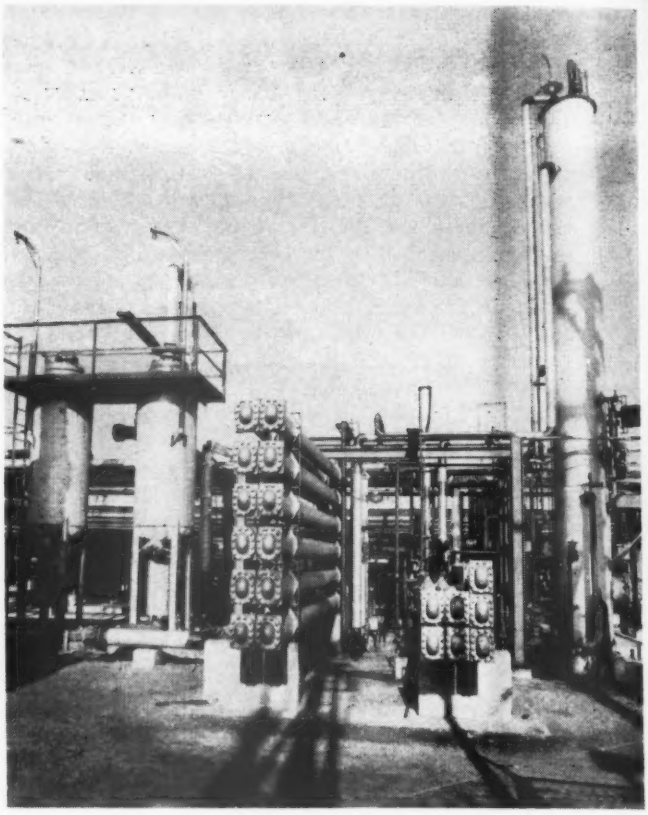


Catalyst reactors at the United Refining Company's Unifining unit. One contains cobalt molybdate for Unifining; the second another catalyst for converting aromatics to naphthenes.



Rear view of United Refining Company's Unifining unit shows the two catalyst reactor chambers, left, heat exchangers, center foreground, and stripper tower, right.

Unifining Makes Better Pennsylvania Kerosine

Double reactor system, for use of two different catalysts produces kerosine that is sulfur-, olefin-, and aromatics-free for special purposes

HARRY A. LOGAN, JR. and W. D. HARBERT

REALIZING that Pennsylvania kerosine has extremely good qualities for application other than burning oil, United Refining Company, Warren, Pennsylvania, determined after the end of World War II to find a way to eliminate its odor, which limited these applications. The accomplishment of this objective would open up a number of new markets by providing a material suitable for solvents, insecticides, paint sprays, liquid detergents, and other specialities.

Although middle-of-the-barrel distillates were already of high quality with respect to low sulfur, odor and color, and had highly paraffinic characteristics, these applications required a kerosine that is entirely free of sulfur, aromatics, and olefins.

The search for a practical means of freeing kerosine of these components without the product losses incurred in the old sulfuric acid treating process was conducted in an independent laboratory with the cooperation of another refiner with the same problem.

After exhausting several approaches it was found that hydrogenation, accomplished over a catalyst, would provide the desired objective. A hydrogenation process became practical by this time because a catalytic reforming process was to be installed in the refinery as a means of upgrading gasoline stocks. It offered a means of utilizing the hydrogen that would be a by-product of the catalytic reforming process.

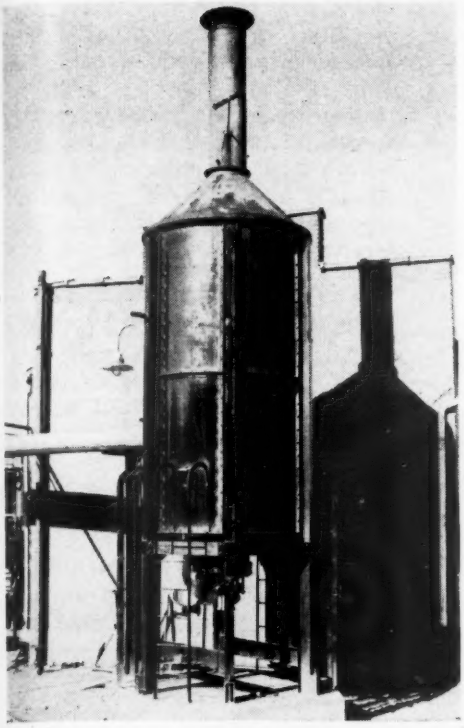
It was then found that the hydrogenation process originally contemplated would not work without some feed preparation because of the sensitivity of the catalyst to certain poisons. The search then shifted to a means of eliminating this problem.

EXCLUSIVE

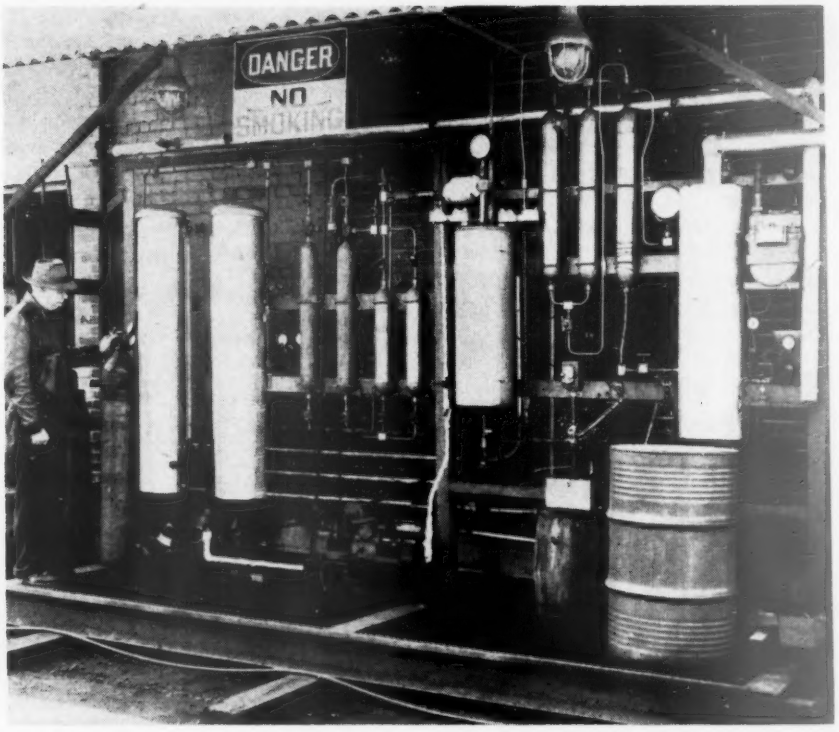
Search for Catalyst

One of the participants in the search for a suitable process was a Blaw-Knox Company engineer who had a part in the engineering and construction of the catalytic reforming unit for United and who had a broad experience in the field of catalytic processes. At his suggestion the investigators were asked to include among others the cobalt molybdate catalyst used in Union Oil Company of California's Unifining*

*Union Oil Company of California trade name.



Charge stock heater for the Unifining process is isolated from the remainder of the unit.



The Unifining pilot plant is still used for small runs. Catalytic reactor is in center, charging vessels on the left, with charge pump below.

process among the feed preparation catalysts which they were trying, and samples of these catalysts were obtained.

The cobalt molybdate catalyst proved to be best, especially because of its immunity from sulfur poisoning, its ruggedness, and long life. Consequently a Unifining license was obtained from the Union Oil Company. A hydrogenation unit of 750 bbl per day capacity was already under consideration by Blaw-Knox at this time. Consequently the program was revised in order to encompass two phases. The objective now was design and construction of a combination unit in which the unifining process employing cobalt molybdate catalyst could be used in preparation of the feed stock for catalytic reforming process and the hydrogenation process employing a nickel catalyst for the final step of converting remaining aromatics to naphthenes in order to produce the highest quality odorless kerosine. Although the original objective was still desired, during the course of the investigation other useful objectives were found to be attainable and of equal or greater value than the first.

The outside research program was concluded when suitable catalysts were determined. Development of a pilot hydrogenation and Unifining plant was continued at the United Refinery by company engineers aided by Blaw-Knox.

Unit Design

As this was to be the first commercial Unifining unit, it was designed by Blaw-Knox with considerable flexibility. The design differs from the usual Unifining unit design in providing two reactor chambers in which different catalysts can be used. For example, in processing kerosine the cobalt molybdate catalyst can be used to decompose sulfur, nitrogen, and oxygen compounds while any remaining aromatics can be hydrogenated by running the kerosine through the unit again, but through the other reactor containing the other catalyst. Pretreating of the kerosine by cobalt molybdate catalyst removes poisons which would otherwise not permit use of the more sensitive catalyst. In actual operations to date, however, it has been found that the cobalt molybdate unifining treatment is sufficient for most applications without any subsequent hydrogenation.

The new process replaced the more expensive and wasteful acid treating process and, incidentally, solved a problem in the disposal of acid sludge. In contrast, the unifining process gives more than 100 per cent product by volume. It is also economical in operation because the reactions are exothermic, thus producing some of the heat required for the reactions.

Process Requirement

The requirement of the Unifining process at the time of its selection was the upgrading of middle distillate products and it was not contemplated that it would be used to desulfurize high-sulfur gasoline stocks. Thermally cracked gasolines which contain unusually high percentages of sulfur and olefins did not, however, constitute satisfactory reforming stocks.

As the Unifining process is highly effective in sulfur removal, and olefin saturation, it was found practical to pretreat these thermally cracked gasolines that were to be later upgraded by catalytic reforming, thus lengthening the life of the reforming catalyst. Economics of this operation are so attractive that treatment of cracked gaso-

The Authors

H. A. Logan, Jr. W. D. Harbert

Harry A. Logan, Jr., is executive vice president of United Refining Company. He is the son of Harry A. Logan, president and one of the founders of the company. Logan is a graduate of Princeton University. He and W. D. Harbert have recently devoted much of their time to an extensive construction and modernization program at United.

W. D. Harbert is chief engineer in charge of refinery operations for United. A graduate of the University of Oklahoma, Harbert was process engineer with Arthur G. McKee and Company before joining United.

line has become one of the principal Unifiner applications. In this process as much as 0.2 per cent sulfur is reduced to 0.008 per cent or less. Thermal gasoline having an octane number of 83 Research with 3cc TEL and poor blending characteristics with finished reformate, is rendered suitable as reformer feed so that United's total gasoline pool consists of catalytic reformate and no further treatment, other than the addition of telraethyl lead, is required.

Depending upon the charging stock being run, operating temperatures and pressures are varied with the unit designed for a maximum of 800 F and 800 lb psi.

Process Versatility

The versatility of operation is indicated by some of the stocks that have been run recently. These include cracked, vis-broken gasoline from Mid-Continent crude, kerosine distillate from Pennsylvania crude to make it stable for storage over the summer months, vis-breaker side-cut to improve burning properties and storage stability, non-viscous neutral to remove sulfur and to improve bromine number, color and stability for use in the manufacture of specialties, mineral seal oil and kerosine to upgrade for use as specialty solvents.

Extreme flexibility has been built into the plant by United in the two reactor system which permits operation with either reactor alone or both in series or in parallel, in the sizing of major equipment which permits increasing capacity to 1500 bbl per day through the addition of heat exchange and a recycle compressor, and in the provision for operation over a wide range of temperature, pressure, and space velocity conditions. * * *

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The ASTM Code requires for conducting a test for vapor pressure of natural gasoline calls for the vigorous shaking of the bomb at 2 min intervals for as long as 20 min. This severe and violent shaking causes the pressure gage to fluctuate widely thereby subjecting the hair spring and linkage to excessive abuse and wear thus shortening the life of the gage and impairing its accuracy.

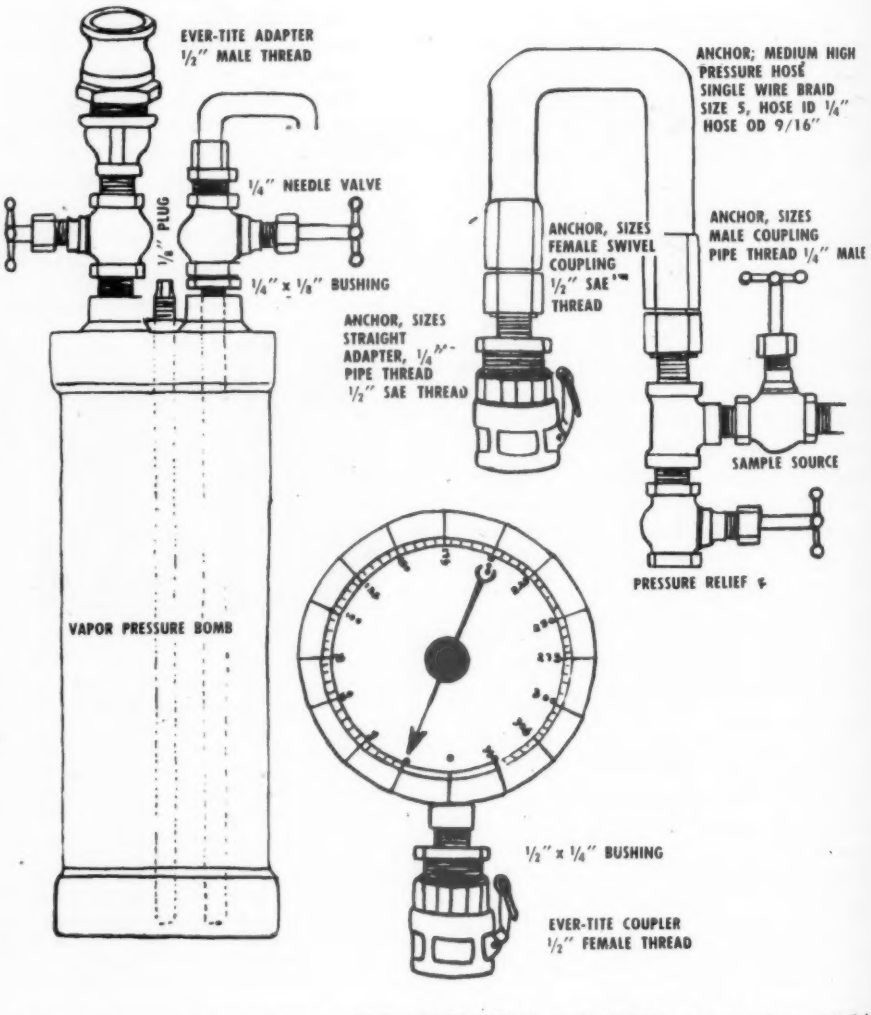
It is proposed that a needle valve and collar be installed on the top outlet of the air chamber and the bomb and sample chamber be assembled for the primarp portion of the test without attaching the pressure gage.

The test is then conducted in the usual manner for the first 15 min or more. After this time, the gage is attached and the needle valve opened. The complete assembly is then shaken and immersed in the bath and brought to equilibrium. Usually no more than a second or third shaking is required in order to secure consecutive gage readings.

Thi device eliminates seven or eight severe shakings of the gage and thereby reduces the abuse and wear on its delicate mechanism. At the same time the accuracy of the test is in no way affected.

*Arkansas Fuel Oil Company, Shreveport, Louisiana.

†Class B, honorable mention, NGAA Kinks



REFINING AND PETROCHEMICAL

PERSONALS

Paul E. Hurley has been appointed manager of Shell Oil Company's Houston refinery. Hurley will succeed **M. P. L. Love,** soon to begin a special assignment abroad. Hurley joined the company as a gager in 1920, and rose through the ranks to become superintendent of the Norco refinery in 1938.

Roy W. Faulk, superintendent at the Norco refinery for the last year and a half, will succeed Hurley as manager. Faulk is a veteran of 25 years with Shell. He was formerly manager of the manufacturing department of Shell Oil of Canada.

G. T. Atkins

George T. Atkins has been promoted to the position of engineering associate at Humble Oil and Refining Company's Baytown, Texas, refinery. A graduate in chemical engineering from Washington University, Atkins will be concerned with the development of design criteria and with the actual design of some of the larger projects being considered for Baytown refinery.

Jack M. Andrews has been promoted to senior research chemist in the research and development division at Humble's Baytown refinery. Andrews has a BS and MS degree in chemical engineering from Texas A and M.

Professors **J. M. Dalla Valle** and **B. C. Moore** have joined the technical service division for the summer vacation period. Dr. Valle, professor of chemical engineering at Georgia Institute of Technology, served as Fulbright Lecturer at University of Milan and University of Nottingham during the past year. Moore is in the department of Mathematics at Texas A and M.

Other staff additions to the technical service division of Humble's Baytown refinery are: **Richard T. Moravek,** Louisiana State University; **David F. Griffin,** Rice Institute; **Don R. Moore,** University of Texas; **Donald A. Foster,** University of Oklahoma; and **W. Kenneth Brinkley** and **Hollie L. Briscoe,** Texas A and M College.

J. J. Samuels recently returned to technical service division after serving two years in the U.S. Army.

Daniel J. McCaustland has been awarded the Socony-Vacuum Fellowship in Yale University for the coming year. McCaustland, son of Mr. and Mrs. G. G. McCaustland, of 7321 Terrace Street, Kansas City, Missouri, received his B.A. degree from Kenyon College. He is studying organic chemistry at Yale.

Alan B. Groh has been promoted to group leader in the pilot plant division at Standard Oil Company's Whiting, Indiana, research laboratories. Groh joined Standard in 1947. He is a graduate in chemical engineering from Johns Hopkins University.

E. Clarence Oden, formerly chief process engineer for Cities Service Refining Corporation, Lake Charles, La., has resigned his position with that company and has opened a consulting office at 1829 Seventh St. in Lake Charles. Oden has had long refining experience, has been with Cities Service since 1944, and was chief process engineer for the last six years. He has also had extensive experience in paints, dyes, rubber, magnesium, and chlorine manufacture. A licensed professional engineer, Oden is a graduate of University of Alabama, and has a MS from Brooklyn Polytechnic Institute.

B. L. Heath of Valvoline Oil Company, division of Ashland Oil and Refining Company, has been elected a director of the Pennsylvania Petroleum Research Corporation. He succeeds **E. M. Craig** of Valvoline Oil Company who retired as a director. All officers of the research group, an affiliate of the Pennsylvania Grade Crude Association, were reelected. They are: **C. A. Chipman,** president; **H. A. Logan,** United Refining Company, vice president; **Fayette B. Dow,** vice president and general counsel; **Samuel Messer,** Quaker State Oil Refining Corporation, treasurer; and **W. C. Wenzel,** secretary.

A. Bruce Boehm has been appointed head of a new rubber division of Enjay Company, Inc. **Walter H. Peterson** will assist Boehm. Peterson has been associated with Enjay marketing activities for the past 10 years. Prior to World War II, he was with Haartz-Mason and in 1942 joined the Synthetic Rubber Allocation Section, War Production Board, which section he later headed. He is presently on part-time loan to the Office of Synthetic Rubber as a technical consultant on Butyl. **Howard R. Moon,** formerly with B. F. Goodrich Company prior to joining Enjay in 1947, has been assigned to the new division.

Dr. Wayne E. Kuhn has been named general manager of The Texas Company's newly-created research and technical department. **James V. C. Malcolmson** has been appointed general manager of the marine department. **Theodore A. Mangelsdorf** has been named general manager of the refining department.

Dr. Kuhn has been manager of the company's technical and research division since September, 1938. The research organization had functioned as a division of Refining; it now has departmental status. Malcolmson has been assistant general manager of the marine department since January, 1952. Mangelsdorf has been manager of the operations division of Texaco's refining department since August, 1953.

Kuhn received a B.A. in science from Reed College in 1925 and a Ph.D. in chemistry from Cornell University in 1929, the year he joined The Texas Company. Malcolmson is a graduate of the Belfast, Ireland, College of Technology. He came to the United States in 1936 as Lloyd's Senior Surveyor in charge of the Philadelphia District.

Mangelsdorf, a graduate of M.I.T., joined The Texas Company in 1933.

M. Halpern

J. S. Worden

F. H. Holmes

T. E. Buchanan

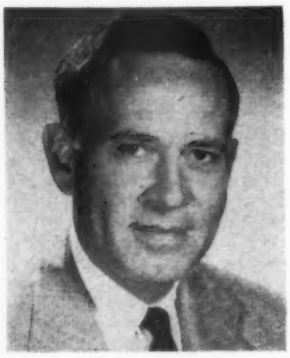
M. Halpern, vice president in charge of refining for The Texas Company, has been elected senior vice president, a new executive post. **J. S. Worden,** former general manager of refining, has been elected vice president in charge of refining succeeding Halpern. **F. H. Holmes,** former assistant general manager of refining, has been elected vice president in charge of the research and technical department, also a new executive post. **T. E. Buchanan,** general manager of the marine department, has been elected a vice president.

Halpern joined The Texas Company in 1916 as an assistant civil engineer at the Bayonne, New Jersey refining terminal. He was transferred to New York in 1930 as assistant manager of the refining department, became general manager of the refining department in 1938, elected a vice president in 1940 and named a director in 1946. Worden joined the company in 1921 at its West Tulsa, Oklahoma, refinery. He was made assistant manager of the refining department in 1940, manager of operations in 1942 and general manager in 1950.

Holmes, a graduate of Yale University, joined the company in 1927. He was made assistant manager (operations) of the refining department in 1950 and in 1953, became assistant general manager of the department. Buchanan entered the employ of The Texas Company in 1917. He resigned 2 years later to become associated with various subsidiaries of the American Republics Corporation. Buchanan returned to The Texas Company in 1938 as assistant to chairman of the board and in 1939 was appointed general manager of the company's marine department.

Personals

Thomas Reis, formerly assistant to the general manager of the French Petroleum Institute and associate professor at the Ecole Nationale Superieure du Petrole, Paris, France, now partner in a French consulting engineering firm and independent research organization, will visit in the U.S.A. in September and October. He will negotiate for several licensing agreements for French companies so they may manufacture American products and equipment for the French petroleum and chemical industries.



R. U. Haslanger

Robert U. Haslanger has been appointed to the administrative staff of Stauffer Chemical Company. Haslanger was formerly director of sales of Monsanto Chemical Company's plastic division. He is a chemical engineering graduate of the University of Wisconsin. Haslanger will be stationed in New York.

W. D. Morrison has been named assistant to the director of the development department of Celanese Corporation of America. Morrison was assistant manager of the product development department of the chemical division of the company.

George T. Piercy has been appointed assistant general manager of the supply department of Esso Standard Oil Company. **J. M. Shivers** succeeds him as manager of the refining coordination division. Piercy succeeds **Thomas W. Moore** who has transferred to the parent organization, Standard Oil Company (New Jersey). Shivers will transfer from the Baton Rouge refinery where he was manager of the refinery crude and marketing division.

A graduate of the University of Minnesota in chemical engineering, Piercy joined the company in 1937 at the Baton Rouge refinery. He transferred to New York in 1951 as assistant coordinator of refining operations and two years later became manager of the refining coordination division. Shivers joined Esso in 1934 as a process engineer. He was named to head the refinery crude and marketing division in 1944. Shivers attended the University of Mississippi and received a bachelor's degree in chemical engineering from Louisian State University. He also did graduate work at L.S.U.

L. O. Lord has been named acting superintendent of Wasson Gasoline Plants in Denver City, Texas by Shell Oil Company. Lord, former gas engineer in Shell's offices at Midland, Texas, succeeds Fray Piland who was transferred to the Houston, Texas office.

W. B. Burgess, superintendent of Humble Oil and Refining Company's gasoline plant at Kilgore, Texas, has been transferred to the Heyser, Texas gasoline plant. He succeeds the late W. J. McDougal.

A. M. Souby has been promoted to research specialist in the research and development division at Humble Oil and Refining Company's Baytown, Texas, refinery. A graduate of Vanderbilt University, with a B.E. degree in chemical engineering, Souby joined Humble at its Baytown refinery in 1939. As a research specialist he will work on catalytic conversion with emphasis on the application of chemical kinetics to process development and design.

C. F. Coffin has been named industrial relations manager at General Petroleum's Torrance, California, refinery. Coffin will also be concerned with the manufacturing department's operations in Vernon, California.

R. O. Traylor, manager of the industrial relations division of Standard of Indiana, has been named manager of a new manufacturing division. **L. J. Frodin,** former superintendent of the industrial relations division, will be assistant manager. **M. H. Madsen,** administrative assistant to the general manager of manufacturing since 1952, will be supervisor of procedures in the new division.

Traylor joined Standard in 1922 and worked at the Casper, Wyoming, Neodesha, Kansas, and Whiting, Indiana, refineries, before being transferred to Chicago in 1950. Frodin, with the company since 1921, has been office manager of the Whiting refinery, personnel supervisor of the manufacturing department's industrial relations division, and last year became division superintendent. Madsen joined Standard at Whiting in 1928 and has worked in the engineering, projects, and industrial relations divisions.

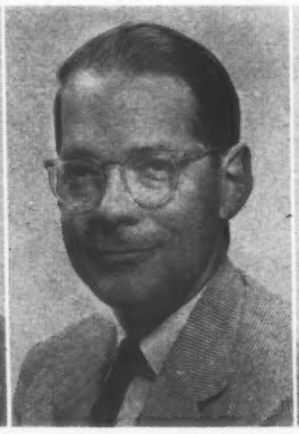
Dr. Harrison Brown, professor of geochemistry at the California Institute of Technology, leaves Pasadena late this month for a 6-month trip that will take him around the world. First stop will be in Rome to participate in the meeting of the International Geophysical Union. He will present a paper on recent developments in the determination of geologic time made by Dr. Claire C. Patterson, senior research fellow in geochemistry at Caltech, and himself. After the close of the meeting, Brown will spend about 6 weeks visiting geochemical laboratories in Switzerland, France, Belgium, and England. From England he will fly to India where he will make a study of Indian resources. This survey is sponsored by the Rockefeller Foundation and will be carried out with the cooperation of the Indian government.

T. Ed Griffith has been promoted from senior engineer, gas utilization department at Houston, Texas, to supervisor of gas and gasoline plant operations in the central division of Tide Water Associated Oil Company at Tulsa, Oklahoma.

A graduate of Oklahoma A and M, Griffith joined Tide Water in 1948. He is a former faculty member of A and M.

Kenneth J. Palmer, former St. Paul, Minnesota, division manager for the Clark Oil and Refining Company has been promoted to regional manager. Palmer will have supervision of the company's Minnesota and Wisconsin operations covering the Brainerd and St. Paul, Minnesota divisions and the Green Bay, Wisconsin, division. He has been with Clark since 1939. Tom Sendecky was named St. Paul division manager to replace Palmer.

F. W. Miner



A. J. Weith

G. C. Voss

Frank W. Miner, has been named district sales manager, with headquarters in Chicago, Illinois, for American Cyanamid Corporation's petrochemicals department. Miner joined the company as a research chemist in 1947. He was assistant manager of the manufacturers chemicals department before his promotion. Miner is a graduate of Cooper Union with a B.S. in chemical engineering, and New York University, with a MBA degree.

A. J. Weith, has been named assistant sales manager of the petrochemicals department. He joined Cyanamid in 1947 as research chemist at the firm's Stamford Research Labbratories in Stamford, Connecticut. Weith was formerly assistant to the director of sales of what is now the petrochemicals department. He is a graduate of Duke University. During World War II, Weith was with the Office of Scientific Research and Development.

George Voss has been named district sales manager of the petrochemical department with headquarters in New York He joined Cyanamid in 1951 at the Idaho Falls, Idaho, plant operated by the company for the Atomic Energy Commission. Voss was formerly sales representative for the intermediate and rubber chemicals department of the organic chemicals division. He is a graduate of Harvard University.

J. C. Pullman has been named manager of technical service of American Cyanamid's petrochemicals department. Pullman was formerly assistant to the manager of the new product development department. A graduate of Mount Allison University and McGill University, Pullman joined Cyanamid in 1943 at its Research Laboratories in Stamford. He was named to the New Product Development Department in 1952.

TOP-PRIORITY SHIPMENT

The sturdiest pump may eventually need a replacement part, the strongest pump suffer accidental damage. In the Gaso plant, this situation is an emergency that calls for same-day shipment of parts, via fastest possible route from diligently maintained stocks. Cutting down-time to the bone is another example of interest that extends throughout the long, long life of Gaso Pumps.

Portable Pumping Unit with Fig. 1654 Gaso Pump

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"tough joint"

Pipeline construction does not stop for snow or cold weather. It's a year-round job these days. Under tough conditions, the welders above are fusing the metal to make a perfect joint of two sections of pipe.

Barrett Coal-Tar Protective Coatings are also designed to "take it." Along with the welds they have to have that same sure fusion that means top protection through every kind of terrain, winter and summer. It's an amazing fact that these Barrett coatings will actually prolong the life of steel pipelines indefinitely, while increasing the cost by only a small fraction. And when you specify Barrett you not only get the finest in protective coatings, but expert technical assistance as well.

The Barrett Technical Service Group, composed of experts in their field, help you pick the best protective coating to meet exacting specifications and yet keep costs to a minimum. In the field, Barrett Service Representatives go right along on the job—checking, advising, assisting in the preparation of pipe and the application of coating.

We welcome the opportunity to place the expert Barrett Technical Service Group at *your* service. For detailed information—phone, write, wire Barrett.

Approved Barrett Applicators are available for field or special work throughout the country. BARRETT DIVISION, Allied Chemical & Dye Corporation, 40 Rector St., New York 6, N. Y. In Canada: The Barrett Company, Ltd., 5551 St. Hubert St., Montreal, Que.

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100 YEARS OF EXPERIENCE

1854 1954 CENTENNIAL Barrett 100 YEARS OF EXPERIENCE

BARRETT PROTECTIVE COATINGS

Deliveries Stepped Up

Daily capacity of the Texas-California pipe line operated by Southern California Gas Company and Southern Counties Gas Company has been increased 150,000,000 cu ft to a total 705,000,000 cu ft with the addition of three 1760-hp compressors in the Blythe station. The recent increase is almost as big as the line's initial total delivery of 175,000,000 cu ft when operations began in November, 1947.

★ ★ ★

Electrical Conference

The first "Electrical Conference of the Petroleum Industry" will be held September 27, 28, and 29 in Tulsa under sponsorship of the Petroleum Industry Committee of the American Institute of Electrical Engineers. Major A. N. Horne, Texas-Empire Pipe Line Company, Tulsa, Oklahoma, will deliver the keynote address. Other prominent personages speakers include A. C. Monteith, newly elected AIEE president and Governor Johnston Murray of Oklahoma. Seven papers of interest to the pipe line industry will be presented.

★ ★ ★

Little Inch Plans Advance

Plans for reconversion of the wartime "Little Inch" (See page D-66, The Petroleum Engineer, April, 1954.) from gas transmission back to transportation of petroleum products took another step recently when Texas Eastern filed application with the FPC asking approval to remove the line from service and build substitute facilities, including approximately 382 miles of new 24-in. line from Beaumont to connect with the company's 30-in. line at Kosciusko, Mississippi.

That part of the present 20-in. line, which extends approximately 1168 miles from Baytown, Texas, to Moundsville, West Virginia, would be used for products service. The line would be operated as a common carrier. Benefits to shippers and consumers would include lower or competitive transportation costs, service to many important marketing areas not presently accessible by products pipe line, and availability of the line for defense use without delay or consumption of then critical materials, Texas Eastern officials related.

The new natural gas facilities, in addition to the 382-mile, 24-in. line, would include 10 compressor stations totalling 86,900 hp, additions to existing stations of 36,020 hp, and 99½ miles of other line. These facilities, said the company, will aid in achieving a more flexible natural gas pipe line system, decrease delivery costs, and provide a system that could later be increased in capacity without increasing transportation costs.

★ ★ ★

Supply Meets Demand

Crude production in the Wyoming-Colorado-Nebraska area has been on the increase in recent years while pipe line facilities to transport it to markets lagged behind. Projects announced recently have made the picture appear much rosier. These include the new Arapahoe Pipe Line, a 480-mile, 18 and 20-in. carrier from northeast Colorado to Humboldt, Kansas, connecting with Sinclair's big inch to Chicago; the Western Pipe Line, a subsidiary of Service Pipe Line Company, that will replace Service's older system between Wyoming and Missouri with a new 630-mile, 20, 22, and 24-in. line; and the current expansion program of Platte Pipe Line, which is adding stations and pumping capacity.

★ ★ ★

Safety Program Planned

Uniformity of statistical information on fleet records of the gas industry and establishment of standards as a basis for analysis and recommendations for corrective action is the aim of a program worked out jointly by the AGA's accident prevention committee and the National Safety Council. An annual safety contest, to cover five classifications of fleet groups, will be held, and trophies awarded to each year's winners.

★ ★ ★

Escalator Talks Delayed

Oral arguments slated for September 30 in Washington by the FPC on the desirability of adopting rules concerning automatic escalation and favored nation clauses in gas purchase contracts by interstate natural gas companies with producing companies has been postponed until November 4. Comments and suggestions will be taken until October 1, and requests for participation in the oral arguments will be accepted until October 15.

Permit Given Trans-Canada

A conditional permit to build a 2240-mile, 30-in. gas line at a cost of $300,000,000 has been given Trans-Canada Pipe Lines, Ltd., by the Board of Transport Commissioners. The interim permit will be followed by a final one provided the company satisfies the commissioners that it has completed financing arrangements and has obtained or will get a Canadian government permit to export gas to the U. S.

Construction of the line would be completed by late 1956.

Route of the line from Alberta would roughly parallel the Canadian Pacific Railroad across northern Ontario from the lakehead through to Toronto. A line southward from Winnipeg would serve U. S. markets in the Minnesota area. Delivery of gas is scheduled to Winnipeg and Minneapolis by late 1955, Toronto by late 1956, and Montreal by late 1956 or early 1957. Completion of the entire line must be by December 31, 1957.

Gas supplies totaling 4.35 trillion cu ft have been assured by the Alberta government, sufficient for a 27-year supply. Of that amount, approximately 540,000,000 cu ft will be taken daily, with 150,000,000 delivered to the U. S.

★ ★ ★

Yellowstone Line Opens

First shipment in the newly-completed Yellowstone products pipe line is expected to reach Spokane in early September. The 540-mile, 10-in. line will handle 30,000 bbl daily.

★ ★ ★

AGA Annual Meet Readied

Plans for the 36th annual convention of the American Gas Association, scheduled for October 11-13, at Atlantic City, New Jersey, are taking final form. Operating section sessions will be held the first two days and will feature demonstrations on remote control of pipe lines.

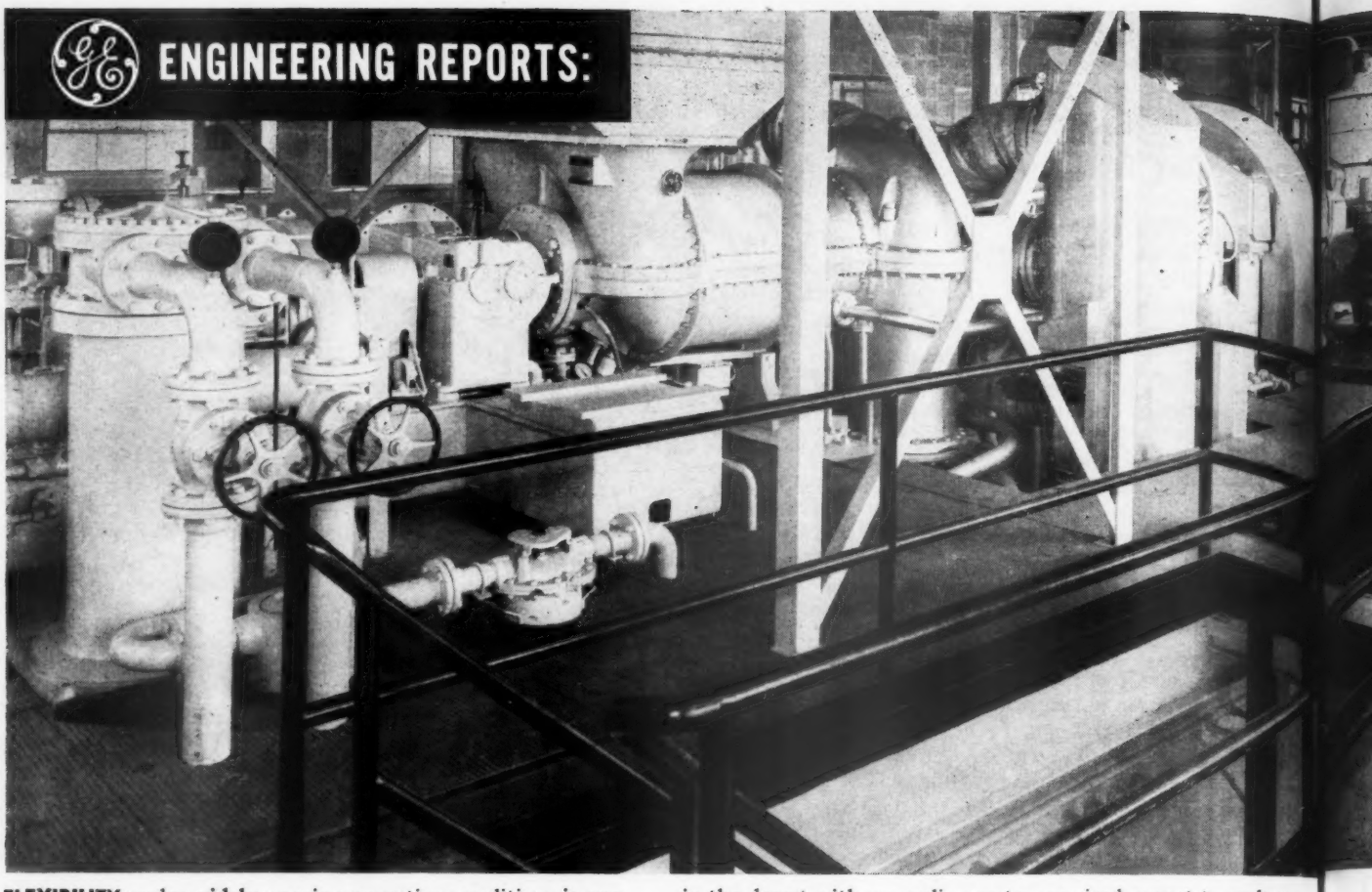
★ ★ ★

"Magic Eye" for Industry

The capacitance recorder adopted for pipe line interface checking by Gulf Oil Corporation's research laboratories, and popularly termed the "magic eye" is being made available to the industry in general. License to manufacture the instrument has been given to Instruments, Inc., Tulsa.

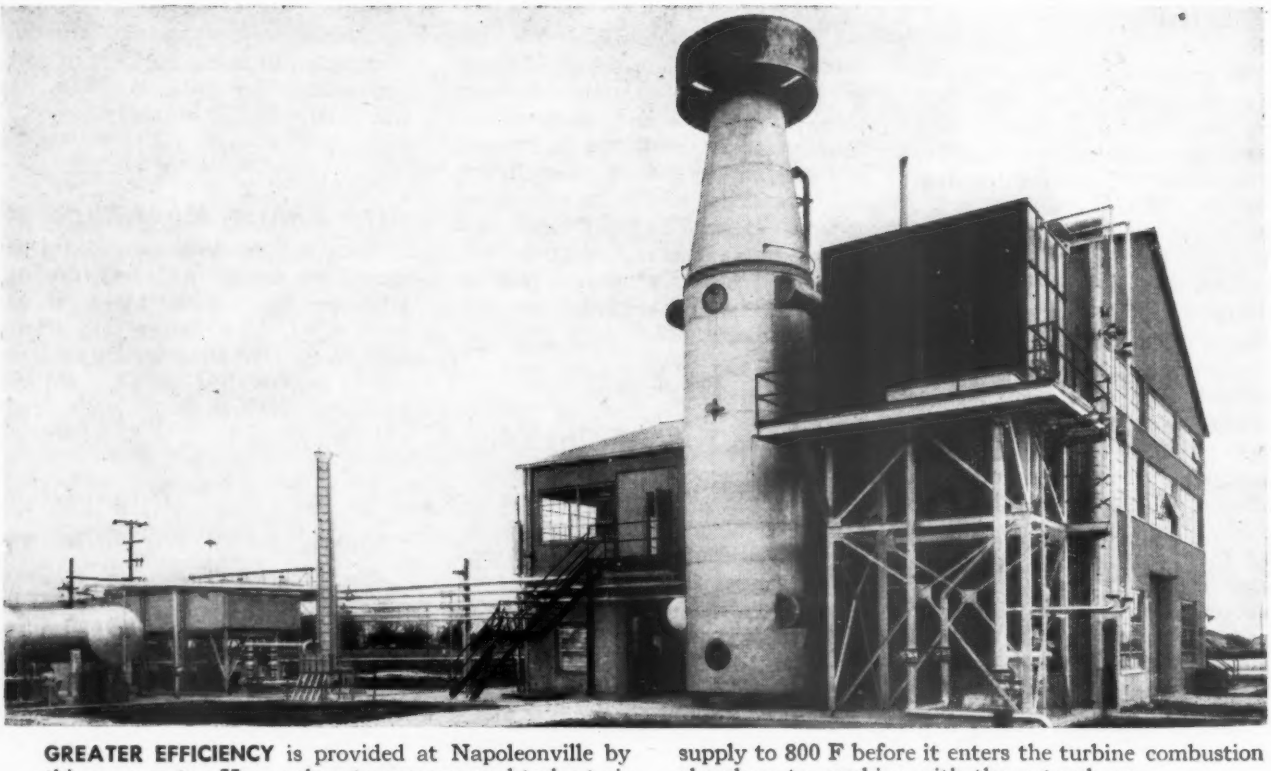
XUM

ENGINEERING REPORTS:



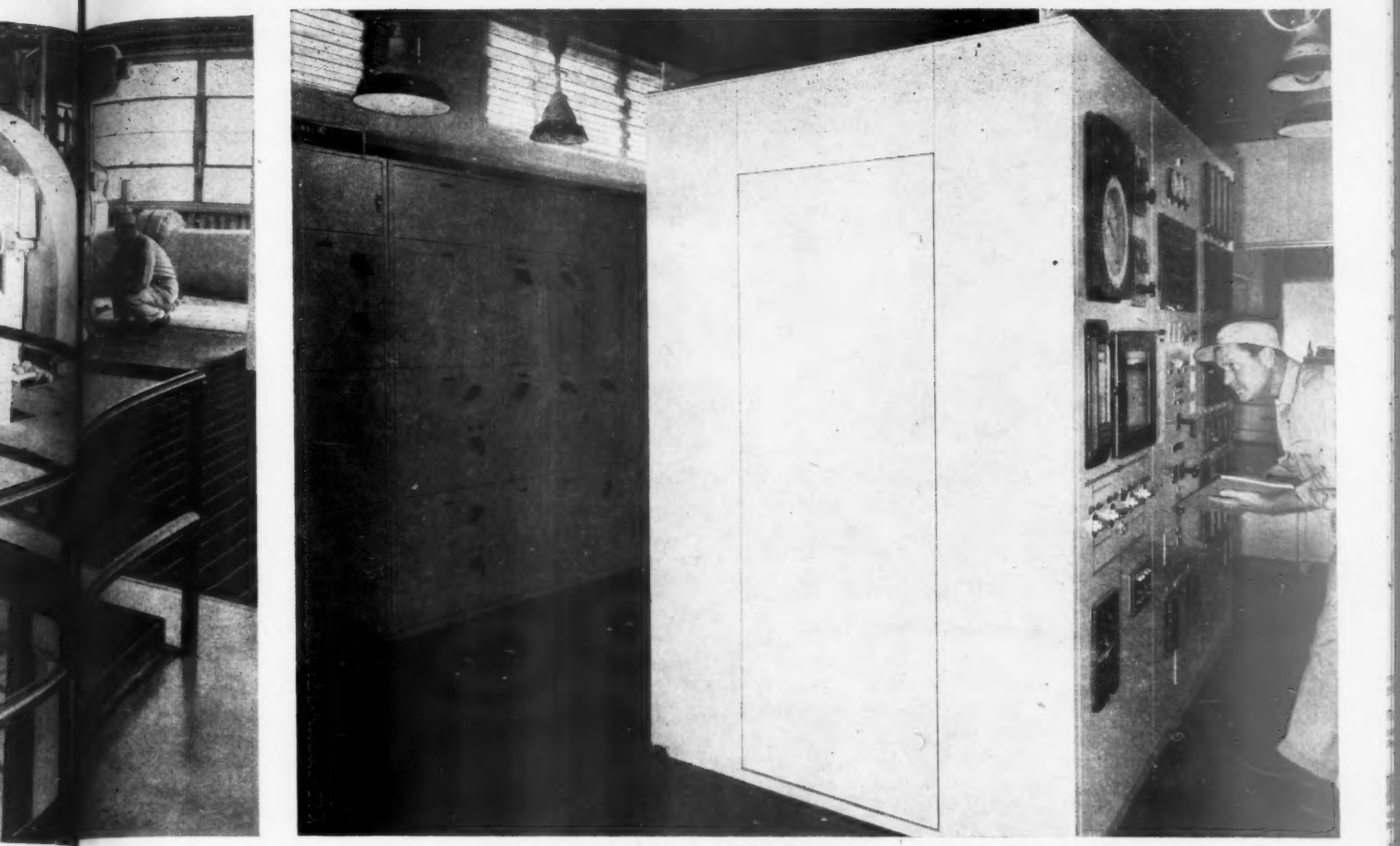
FLEXIBILITY under widely varying operating conditions is one advantage of the G-E gas turbine. It can even be operated in the desert with no cooling water required except to replace very small losses in recirculating.

G-E gas turbine helps United Gas



GREATER EFFICIENCY is provided at Napoleonville by this regenerator. Here, exhaust gases are used to heat air supply to 800 F before it enters the turbine combustion chambers to combine with the natural gas.

XUM



COMPACT, COMPLETE, CONVENIENT, the control equipment consists only of a starting and supervisory control station and an auxiliary control panel.

reach all-time day delivery peak

Pumps 510,992,000 cfd in first use of gas turbine-driven centrifugal compressor as initial main-line station

Four billion cubic feet per day of natural gas—that's the record delivery set in December, 1953 by United Gas Pipeline Co. Of this total, 510,992,000 cubic feet were pumped through United's new Napoleonville, La. station by a General Electric gas turbine.

Called in early in the planning stage, G-E engineers assisted United's engineers in the design of the main compressor building, and helped co-ordinate electric equipment with the 5700-hp gas turbine. Equipment delivery was carefully timed by G-E engineers to help complete the station on schedule. And the station has been continuously available for service since it first went on the line.

In your operation, too, a G-E gas turbine can pay big dividends.

Cuts total yearly costs. It needs fewer operators than other types of pipeline drive—only seven men are used. With few moving parts, all rotating and easily accessible, maintenance costs are low.

Provides more horsepower. It produces more horsepower in cold weather, supplying up to 25 per cent more horsepower in the winter, when demand is greatest. Rotation speed is easily changed from 2000 to 5500 rpm to meet varying load conditions. And it starts fast—in 15 minutes, automatically, at Napoleonville.

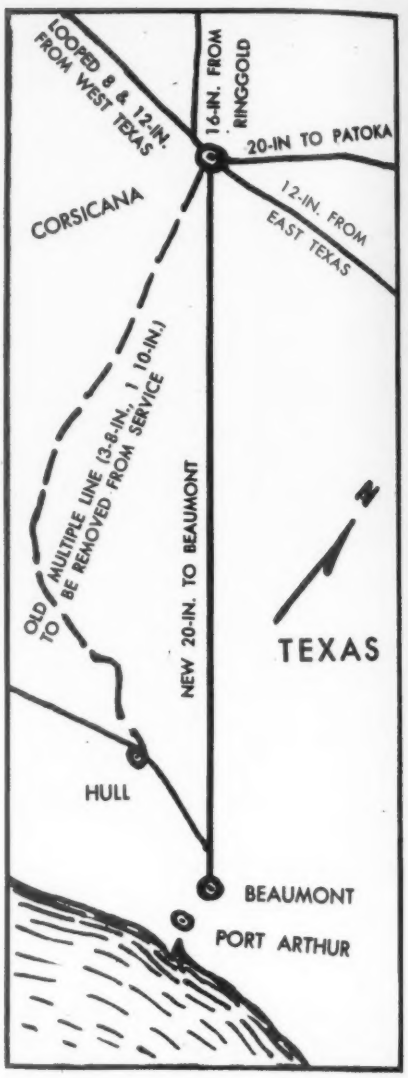
When you plan to increase gas throughput, do as United did—avail yourself early of the many specialized G-E engineering services offered through your nearest G-E Apparatus Sales representative. General Electric Company, Schenectady 5, N. Y. 661-45

Combustion Gas Turbines for the Gas Pipeline Industry—Backed by 45 years of Turbine Leadership

GENERAL ELECTRIC

Backhoe cutting trench in creek channel in South Texas.

P 615.05



Map shows route of new line between Corsicana and Beaumont, lines to be removed from service, and other lines into the central gathering point of system at Corsicana.

New 205-mile, 20-in. line, replacement for old multiple line system, constructed ahead of schedule despite weather, other obstacles

Beaumont — Corsicana Link Completed

DEAN HALE*

MAGNOLIA Pipe Line Company's new 205-mile, 20-in. crude oil trunk line between Corsicana and Beaumont wouldn't present any problem to a crow flying between the two cities. The line's route follows an almost straight line. Newest link in Magnolia's crude transportation system, the 20-in. line replaces an old multiple line system composed of three 8-in. and one 10-in. lines between the 2 points. Approximately 202 miles of the old 4-line system, between Corsicana and Hull Junction will be removed from service as the 20-in. goes on stream. The balance of the old system between Hull Junction, where lines from southwest Texas tie-in, and Beaumont will remain in service.

Crude for the new line originates in Oklahoma, North Texas, West Texas, and East Texas and is delivered to the central gathering point at Corsicana through a 12-in. East Texas line, a looped 8 and 12-in. system from West Texas areas, and through the 16-in. line from Ringgold, completed earlier this year, which carries Oklahoma and North Texas crudes. From Corsicana, the outgoing stream is split between the Beaumont line and Magnolia's Corsicana-Patoka 20-in. trunk, completed in 1948.

Initial capacity of the line will be 124,000 bbl per day, which could ultimately be increased to 165,000 bbl per day with the addition of a full boost station at Groveton. Provision for such a booster station was made in the line design and a site is available if needed. The capacities of the system were designed on factors of 50 SUS viscosity, .83 specific gravity, and 100 per cent load factor. Under normal conditions, the line will operate at a discharge pressure of 1000 psi at Corsicana.

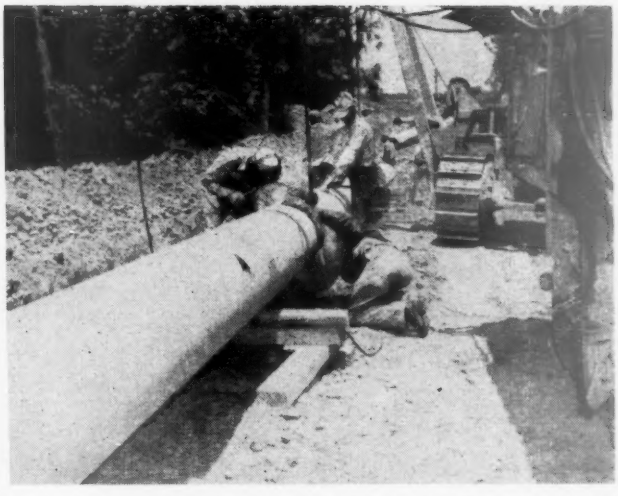
New facilities at the Corsicana station have been constructed for operation of the new line. Three 1250-hp electric motors driving centrifugal pumps will provide the needed pumping capacity. An additional mixing station, which mixes various types of crude received at Corsicana into a common stream, is also being constructed.

Additional tankage at Corsicana includes two 120,000 bbl floating roof tanks with remote reading tank gages and additional tank farm line. All valves installed in the pump station facilities are motor operated.

A flowmeter installed on the station discharge line, which records crude movement for a 24-hr period, also gives a continuous barrel per hour reading on a gage located in the central office

*Editor, Oil-Gas-Products Pipelining.

EXCLUSIVE



Left, lowering in 20-in. line in central Texas. Right, welding pipe joint in area where soil was dry. Rain caused delay on parts of job.

through use of a remote transmitter.

At Beaumont, all crude is delivered to Magnolia refining tankage through meters that automatically record deliveries. Six new 122,500 bbl tanks and connecting lines are being installed at the Beaumont site to accommodate the deliveries.

Construction

Careful planning and favorable weather enabled Magnolia to complete the line construction in shortly over three months, approximately one month ahead of the contemplated deadline. Construction began in April, starting on the south end of the line near Kountze. In this area, the line crosses numerous rice fields. The gamble to start work early here paid off well, with nature cooperating by providing dry weather that enables crews to lay pipe rapidly through the rice fields. Damage to crops was prevented and construction forces weren't faced with being bogged down in mud as they beat the "rainy season."

The line was laid in a conventional manner except in those instances where conditions of terrain necessitated otherwise. The southern end of the line, near Beaumont, was through wet country, crossing bayous, marshy terrain, and numerous small streams, canals, and drainage ditches. Difficult sectors met by the contractor included the thickly timbered area in Hardin County during rainy weather and about five miles of quicksand in Houston County, just outside of Crockett, which hindered the progress of the work considerably.

Little rock was encountered in the construction. In areas where solid rock was encountered, however, with no top soil cover, ditch was blasted to allow sufficient depth for placement of pipe plus a minimum 12-in. cover to ground level.

In areas where rock and top soil cover were encountered, ditch was excavated sufficiently deep to insure placing of pipe 4 in. below the top level of the rock or to give a normal 18-in. cover. In all cases, a minimum 12-in. cover was made.

Normal ditch was excavated to a 40-in. width and 40-in. depth, with a round bottom. A minimum 6-in. soil pad was placed over coated pipe in the rocky areas before backfill was made.

In areas where advantageous, "A" frames were placed under the line to span creeks and washes, in place of excavating ditch. At irrigation and drainage canals on the southern end, overhead crossings were made. North of Pine Island bayou, the "A" frames were used to support the pipe and south of that point, "H" frames were used.

In all, the line has 35 water crossings, including the Trinity River, 18 smaller creek and stream crossings, three bayous, and 13 canals and drainage ditches.

Three of the crossings, the Trinity River, Richland Creek, and Tehuacana Creek, were made in an unusual although not totally uncommon manner, through use of 20-in. pipe cased with 24-in. and the annulus filled with bituminous material. This method gives added weight and security for the crossings.

Pipe and Protection

Of the total 204.87 miles of 20-in. OD pipe used, the first 32.02 miles of high pressure line from Corsicana station was laid with ⅜-in. wall thickness, plain end, electric weld line pipe weighing 78.60 lb per lineal ft. The remaining 172.85 miles of line pipe used was 5/16-in. wall, plain end, weighing 65.71 lb per lineal ft. All pipe furnished was double random length. Pipe is standard x-46, with yield strength of 46,000 psi.

Approximately 93 miles of the pipe was coated and wrapped over the ditch and the remaining 112 miles was yard coated and wrapped in Houston and delivered to the right of way. Yard coated pipe was cleaned and primed, given a 3/32-in. enamel coating, and single wraps of glass fiber and 15-lb perforated felt. *(An article describing a method of yard coating used for part the pipe on this line appeared on Page D-16, The Petroleum Engineer, July, 1954.)*

Pipe receiving over-the-ditch coating and wrapping was cleaned and primed, given a 3/32-in. coat, one wrap of glass fiber, and one wrap of 15-lb coal tar impregnated asbestos felt.

Right of Way

Right of way for the line was, in most cases, 50 ft in width. In some areas, to minimize damage hand ditching was performed. Where timber on right of way exceeded 6-in. in diameter, it was sawed at ground level and cut into logs of approximately 12 ft in length. Disposal of small timber and brush was accomplished through carefully controlled burning.

Welding and Bending

All welding was done manually, by the shielded arc metal method and done by the downhill method over ditch, using stove pipe lineup. Inspection of line welds was done visually and regular physical tests were used for welder qualification.

Bending was required only where changes in grade were such that pipe would not naturally lay on the bottom of the ditch.

Joint ends of the yard-coated pipe, after welding, were hand-cleaned with wire brush, primed, and asbestos mold field jointers were installed. The annular space between the field jointers and pipe was filled with enamel. The field jointers were held in place with ¾-in. steel bands. A holiday detector

Left, installing road crossing. All crossings were cased with 24-in., insulated, and test leads installed. Right, large part of line was laid through rolling, timbered country. Pipe here was yard coated, dope gang are making field joints.

was used to check coatings on all over-the-ditch coated pipe, yard-wrapped pipe, and the field coated joints on yard-wrapped pipe.

Rail and Highway Crossings

At all class A roads and beneath railroads on the line route, crossings were bored and cased pipe installed. All casings were insulated from the pipe line with advanced type casing insulators. Test leads were installed and were attached to the coated pipe or casing through cadweld bonds. All test lead connections were coated and covered with felt.

Gate Valves

Block valves of the through-conduit gate valve type, gear operated, 20-in., 600 lb ASA, were installed on both sides of the Trinity River, Richland Creek, and Teuhacana Creek crossings, and at the proposed booster station location near Groveton. Gates were also installed at other vantage points on the line. The valves were placed on 4 by 4 by 2-ft reinforced pads, and were insulated. The gates and flanges were coated with enamel to a ¼-in. thickness. Scraper traps were installed at Corsicana and Beaumont.

Line Testing

As sections of the line were completed, a hydrostatic test was applied, normally in lengths of 45 to 50 miles. A standard pipe line scraper was run ahead of the water as it was pumped into the line to insure proper clearance internally and to locate any projections or icicles not previously eliminated.

Procedure in the test was to close the gate valve, fill the line with water using centrifugal pumps, raise the pressure to 1000 psi and hold for 24 hours, reduce pressure to 350 psi and then raise again to 1000 psi for another 24 hours.

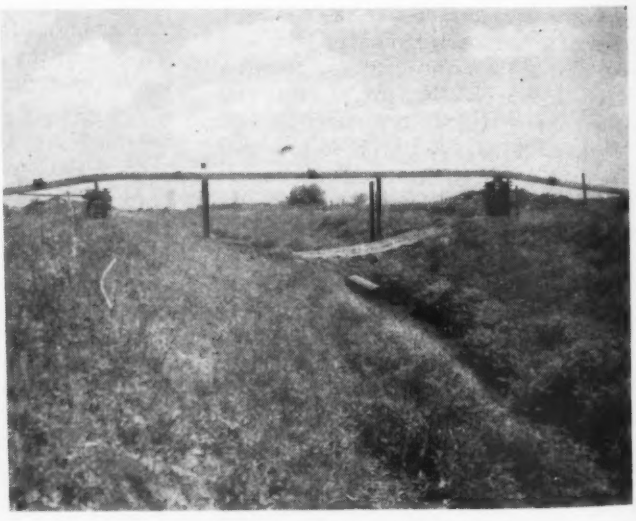
Air in the line was removed through use of bleeder valves installed at high points along the section being tested, as well as removal through the open end of the line.

During the test when pressure was being maintained at 1000 psi, the line was patrolled by both airplane and personnel on foot, checking for possible leaks. Recording gages were also used to check on pressure drops.

Water was injected into the line in amounts adequate to insure a rate of progress of 1 to 1.5 mph, using centrifugal pumps. For the pressure test, 4 by 6 reciprocating pumps were used, with 3½ and 2-in. liners used as pressure was increased.

Contractor for construction of the line was H. B. Zachry Company, San Antonio. Dunn Brothers, Inc., Dallas, subcontracted stringing.

Considering the territory over which the line was laid, time of year the job started, and muddy terrain from rains in the big thicket area of southeast Texas, the contractor completed the job ahead of schedule and to the company's complete satisfaction. * * *

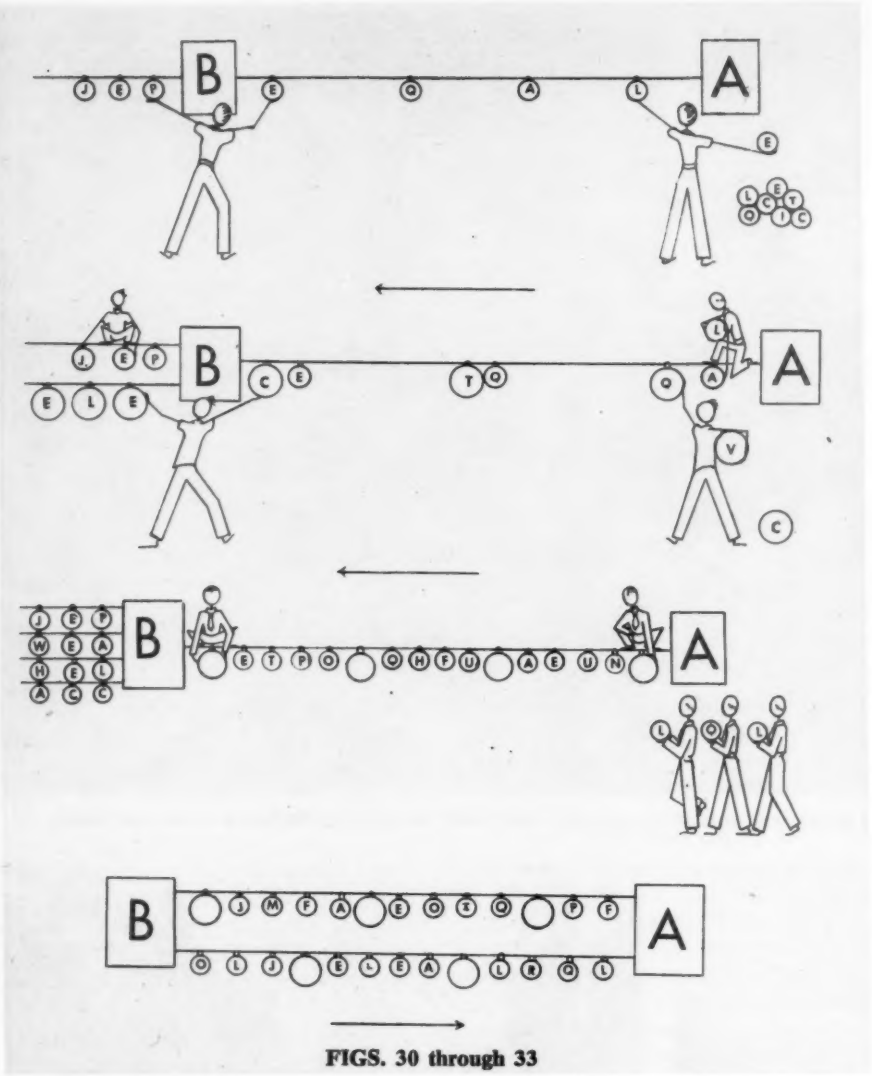


Left, driving piles for canal crossing. Right, canal crossing in place, piles driven, and awaiting installation of "H" frames.

Right-of-way after backfill and cleanup. Small brush was burned in carefully controlled fires. Large timber was cut and sized.

Rainy weather encountered during construction caused delays, made it necessary to pump water from ditch at many low spots.

Firing line on the Beaumont-Corsicana 20-in. Soil here was partially rocky.



FIGS. 30 through 33

FIG. 29. Frequency allocation chart.

Channel	Cycles
1	0— 3,000
2	5,000— 7,800
3	9,000—11,800
4	13,000—15,600
5	17,000—19,800
6	21,000—23,800
7	25,000—27,800
8	29,000—31,800
9	33,000—35,800
10	37,000—37,800
11	41,000—43,800
12	46,000—47,800

Fifth of a Series

P 615.365.1

Microwave System Design

W. E. SUTTER*

TODAY there are two fundamental methods of multiplexing: Time division and frequency division. Time division was not possible for voice communication until the opening of the microwave band, because spectrum space was not previously available. Frequency division in one form or another has been applied to telephone circuits for a number of years.

In frequency division, the basic principle is the same regardless of the techniques. Early developments took the form of amplitude-modulated sub carriers with both side bands transmitted. In most present day equipment, only one side band is transmitted and the carrier is suppressed. Thus, if the upper side band is transmitted and the sub carrier of 10 kc is modulated by a 300-3000 cycle voice circuit, it would appear as a signal with side-bands from 10,300-13,000 cps. A guard band of approximately 1000 cycles may be set up above and below this signal and then the process can be repeated. The frequency allocation chart for this equipment is given in Fig. 29.

Recently, there have been additional changes made, presumably, in order to improve the performance of frequency division equipment in microwave systems. Several systems in the early stages of installation suffered greatly from cross talk, as it was impossible to keep the system linearity within predetermined limits, especially when there were a large number of repeaters required. This became increasingly serious when a large number of channels were being transmitted. As the intelligence is being continually transmitted for all channels simultaneously, the levels of each channel required extremely careful adjustment as the modulating voltage that the transmitter can accept has a certain top limit, and as channels are added, the amount assigned to each must be reduced.

For these reasons, the recent trend has been to move from the lower sub carriers up to the 300 kc to 800 kc region. One system utilizes the 300 to 600 kc region, while a second is now employing the 400 to 800 kc band. This places all of the voice channels in one octave and harmonic distortion, which under normal conditions would cause cross talk, falls outside the bands.

Time Division Method

The second method, time division multiplexing, employs a signal and principle very similar to that which provides us with our home television picture. Pulses, synchronizing circuits, etc., are all present and operate in a similar manner.

In a time division system, samples of each voice channel are taken in a fixed time sequence at a speed or rate so high that it is impossible to notice that the conversation is merely sampled and not sent continuously. The over-all effect is similar to that which

*Commercial microwave engineer, General Electric, Electronics Park, Syracuse, New York.

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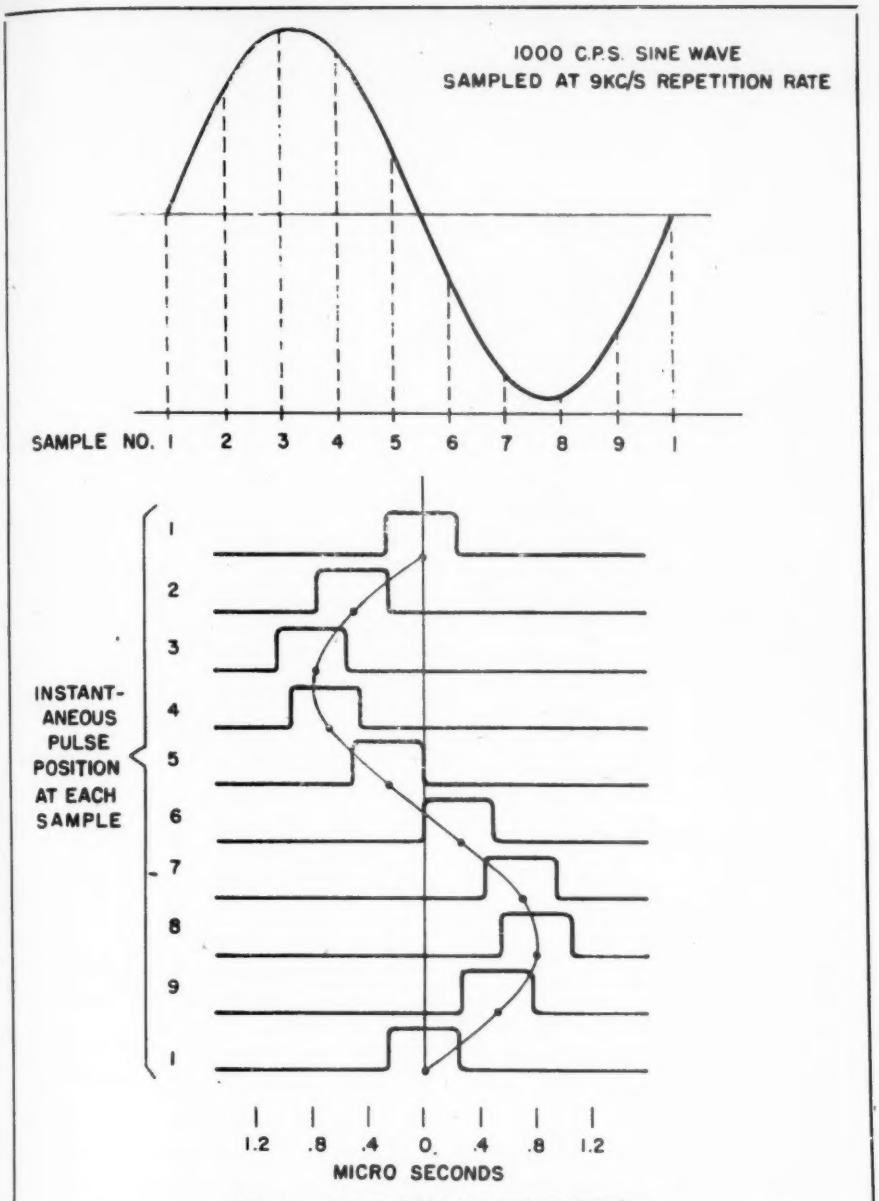


FIG. 34. Typical PPM channel modulation.

the eye experiences when witnessing motion pictures.

Here is one of the best ways to explain time division multiplex in very simple terms. Looking first at Fig. 30, suppose for a moment the system consists of two stations, A and B, connected together by a continuously moving belt, and we wish to transmit messages from A to B. At A we have a large supply of beads, each having a letter of the alphabet on it.

By selecting properly-lettered beads and hanging them on the belt that is moving toward B, the desired messages can be spelled out and transmitted. As the business of selecting properly lettered beads and hanging them on the wire takes some time, there is a considerable space between beads, and it is at once obvious that a second person at A could transmit another separate message simultaneously by using a second set of beads hung on the wire in the spaces between the first beads. In order to avoid confusion in separating the two messages at B, we find it more convenient to use different size beads for the two messages, as illustrated on Fig. 31.

As there is still a lot of room between beads, and more people want to send messages from A to B, it appears that the system will have to be extended to use all of the space between beads. By having each of the persons transmitting at A line up and hang a bead on in sequence, and having the small boy operating the system at A hang on a large bead at the beginning of each sequence, we have such a system as shown on Fig. 32. The small boy at B decodes the messages by sorting the beads in the same sequence used at A after each large bead.

By utilizing the return belt to carry similar messages as illustrated in Fig. 33, we have a two-way multiplex communication system.

In this analogy it is obvious that the moving wire belt is a microwave carrier and the beads are pulses of carrier energy each containing a sample of the information being transmitted. The large spacing or sequence beads

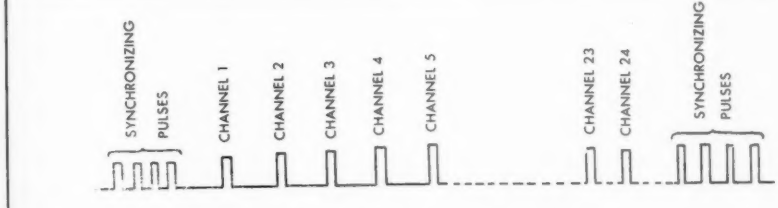


FIG. 35. Pulse train of a time-division multiplexing system.

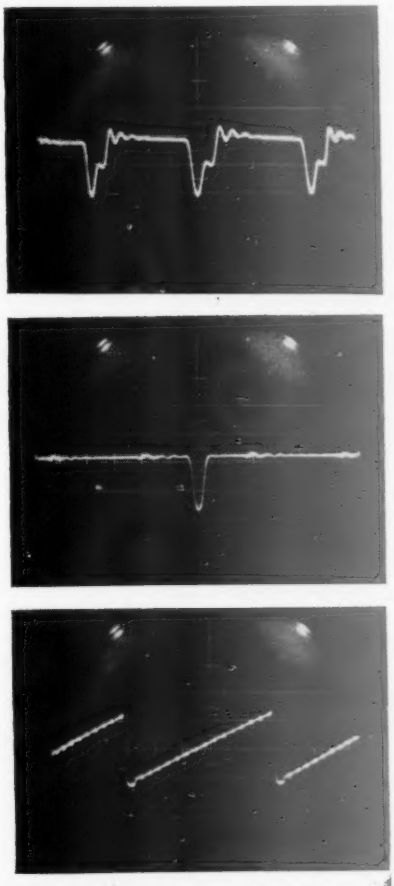


FIG. 36. Troubles on system are easily visualized through use of an oscilloscope. Typical disturbances are shown in these three 'scope pictures.

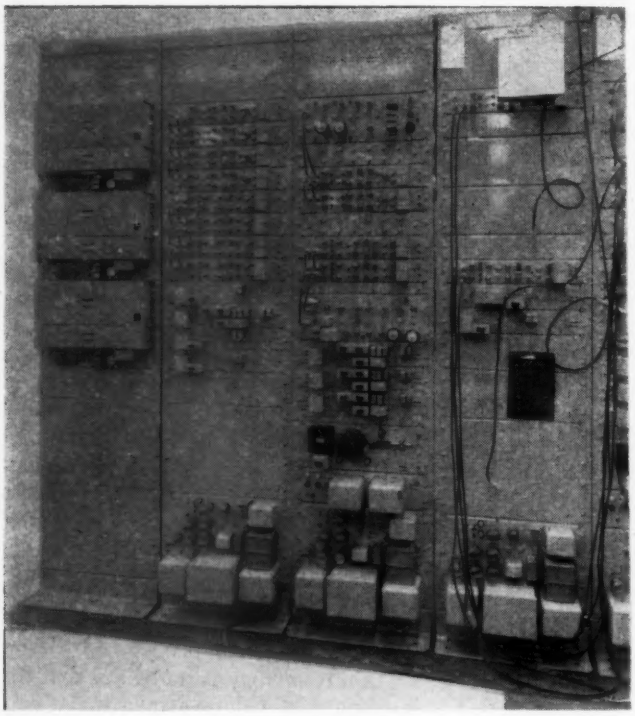


FIG. 37. Typical multiplexing terminal.

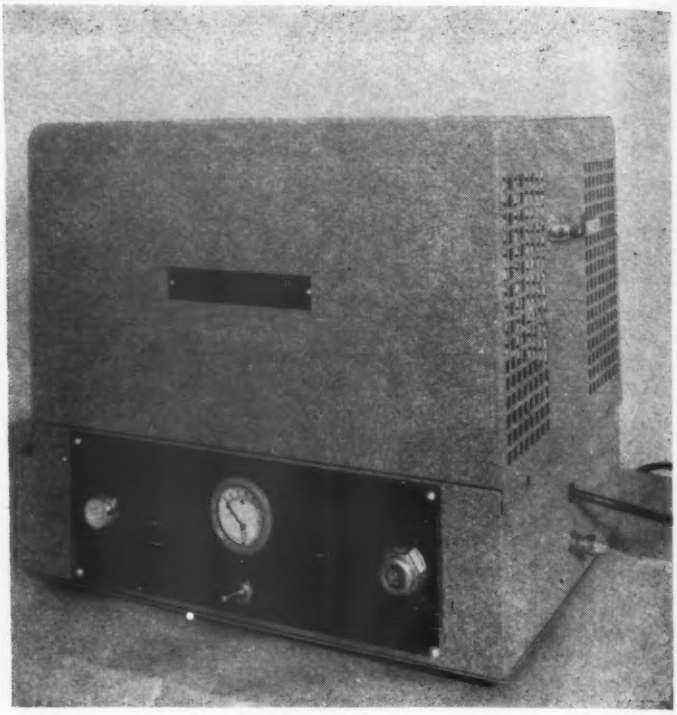


FIG. 38. Automatic dehydrator used to keep air dielectric lines free of moisture.

correspond to the synchronizing impules used at the beginning of each sequence of channnel pulses. The information sample can be imparted to each of the channel pulses by changing its width, amplitude or position in relation to the synchronizing pulse.

Pulse-Position Modulation

In a time division system the various audio input signals are sampled several thousand times a second. The modulators sample the incoming audio signal and the amplitude of the voltage at the time the sample is taken determines the position of the individual channel pulse. This system is called pulse-position modulation. When the modulation is large, the displacement of the channel pulse is large and conversely if the modulation is small, the displacement is small.

Note Fig 34.

As the sampling rate for each channel is only once every 107 microseconds and the pulse displacement from the average position is only a small fraction of the total time, the remaining interval can be utilized by the pulses of other channels which are interleaved as illustrated in Fig. 35. A synchronizing impulse made up of 4 pulses marks the beginning of the sample series and is used by the system for referencing all channels. By limiting the maximum displacement each channel is made independent of all others. Cross talk is virtually eliminated since only one conversation per channel is transmitted at one given instant.

Actually, the number of samples required per cycle can be greatly reduced by passing the demodulated audio through a low pass filter, which will attenuate the harmonics. Laboratory tests have shown that distortion can be held to the very low level of 3 to 5 per cent by taking as few as 3 samples per cycle at the highest audio frequency. As good commercial telephone circuits do not pass frequencies higher than 3000 to 3500 cycles per second, a sampling rate or pulse repetition rate approximately 9000 cycles is satisfactory.

These pulses are transmitted as bursts of RF energy at the rate of 300 kc. This is not a difficult operation and therefore the transmitter can be a very simple unit. It requires only a source of the 2000 mc carrier and a keying tube to turn the energy on and off.

Non-Linearities

The use of time division multiplexing eliminates one of the major difficulties encountered in a frequency division system. In our discussion it was obvious that particular attention was given to the non-linearities in the RF stage in order to keep the cross talk and noise from becoming a serious problem. This effect is cumulative so that it becomes particularly disturbing in relaying over long distances, or when there are a great many channels in operation, as all the signals are present all the time.

In a time division system, however, only one pulse representing one channel is present in the system at any particular time. The next pulse does not appear until the preceeding pulse has completed its excursion and there is a large inactive period in between to assure that there will be no overlap.

Momentary distortion of the pulses do not affect or appear in the audio output and the pulses can be repeated over and over again without serious deterioration of the audio signal. Although the pulses may actually be misshaped in transmission, they can be reshaped at each repeater station without harm to the audio because the intelligence is in the position of the pulse and not in its shape.

Another advantage of time division multiplexing lies in its ability to eliminate the noise accumulated during transmission by means of clipping circuits. After passing through accurate clipping circuits, the noise components are eliminated.

This signal-to-noise improvement can be accomplished in any pulse where the intelligence is not contained in the amplitude of the pulse. Any pulse width or pulse position system can incorporate this improvement, which amounts to as much as 10 to 15

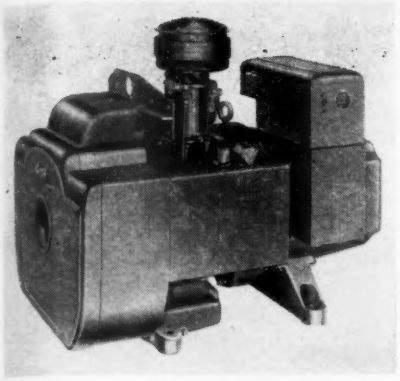


FIG. 39. Five KW air-cooled generator.

db improvement in the signal-to-noise ratio.

We all know the old proverb, "A picture is worth a thousand words." If we paraphrase it a little, however, it becomes a further advantage of time division multiplexing, "A picture is worth a thousand measurements."

Oscilloscope Testing

Consider for a moment the advantage of having before your maintenance organization at all times a single comprehensive picture that tells at a glance what is happening on each and every channel. When a trouble develops along the system, only a rapid comparison check of the pulse train is needed to isolate the difficulty. Because time division is essentially a picture system, an oscilloscope constitutes the major test equipment necessary. Wideband scopes such as Tektronic Models 315 and 511 or Dumont 303 which have an expanded sweep that allows visual inspection of each channel pulse in detail despite the fact that it is only 0.5 microseconds wide have proved quite useful in this respect.

Fig. 36 illustrates this process with several basic pictures.

Equipment

A typical 6 channel multiplexing terminal is shown in Fig. 37. This equipment provides all the necessary circuits to multiplex from 2 to 24 channels. The design of the terminal equipment is extremely flexible so that any installation can be expanded by the addition of simple modulators, demodulators, power supplies, and termination units. The basic synchronizing circuits are incorporated in the 2 wave form generators, while all of the modulating and demodulating circuits are on the small modulator and demodulator panels.

The necessary terminating equipment such as hybrid, signalling, and the like is accomplished by means of another chassis which is determined by the service to be performed. Each channel is capable of providing an audio circuit of 300-3500 cycles.

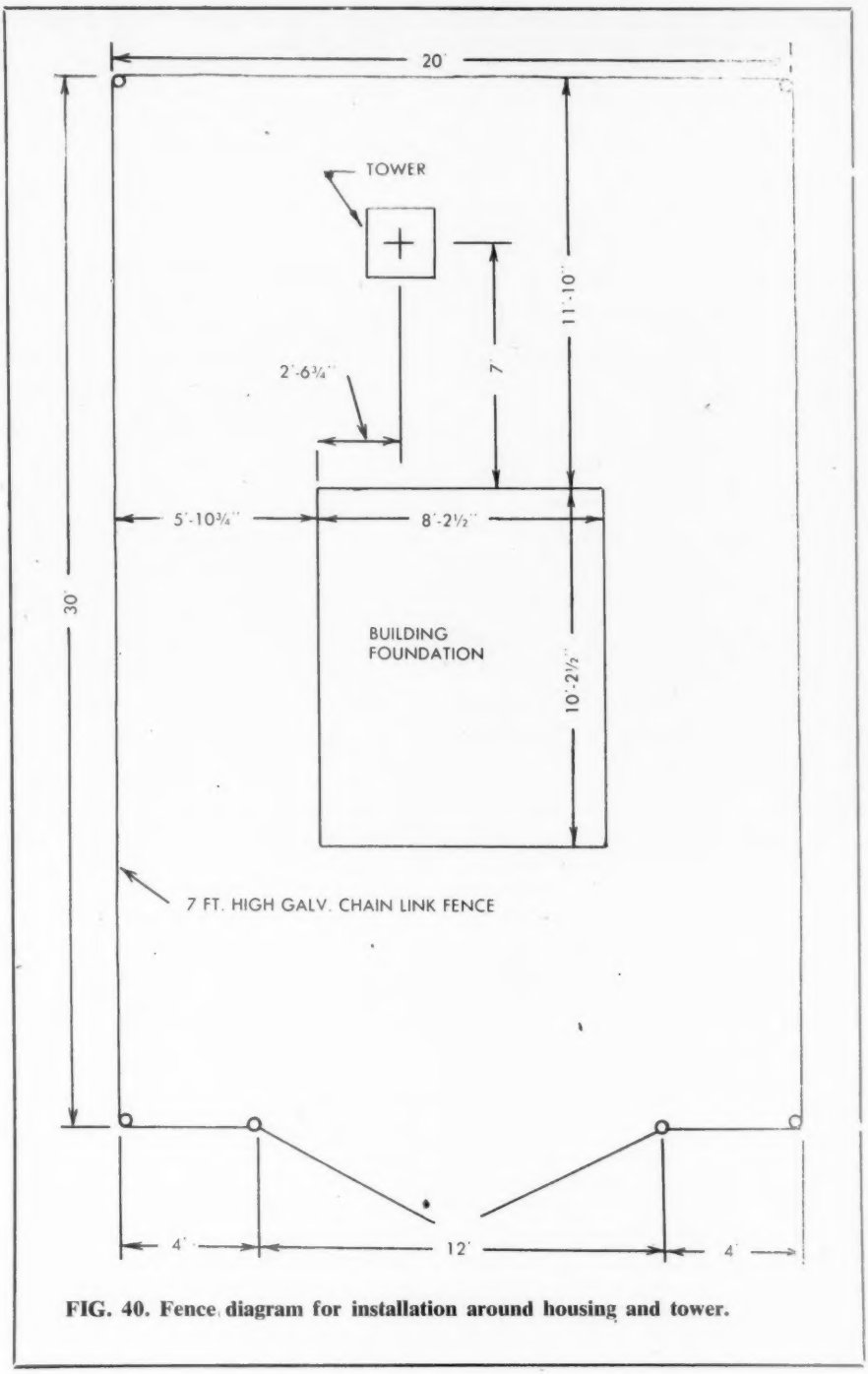


FIG. 40. Fence diagram for installation around housing and tower.

The multiplex equipment used at repeater stations is called a drop-and-insert assembly and it is provided in two basic forms: the multi-channel drop and insert and the service channel drop and insert. The multi-channel assembly is used to provide audio and signaling circuits at repeater stations where only a portion of the total number of channels passing through the station are made available for use at the station. This equipment does not affect the through channels but provides two or four wire termination for these channels where audio is desired either on a party line basis or as one-way or two-way independent circuits.

The service channel equipment is used to provide communications with these through repeater stations. A simple service channel unit is used which will make the service channel available.

Each station must be supplied with the necessary phone equipment that it requires. In addition, talking batteries and a 20 cycle sub-ringer are necessary and under certain conditions, PBX and PAX equipment may be required.

Where there is any doubt concerning the regulation of the primary power, it is recommended that a voltage regulator be supplied. Almost all electronic equipment is voltage sensi-

XUM

tive and the power input should be held within plus or minus five per cent.

Regulators of sufficient size to handle the power requirements of the RF and multiplex equipment present should be installed. This includes the standby equipment also. The tower lights, building lights, and other power requirements should be supplied from a separate non-regulated supply.

When air dielectric lines are employed to feed the antenna, automatic dehydrators should be provided. These units, Fig. 38, have an automatic recycling process so that the lines are continuously freed of moisture. Only one is necessary at any station since its normal capacity exceeds the normal need of any station.

Lightning Protection

A great deal of attention should be given to lightning protection as many installations report that lightning strikes their towers regularly. This is not difficult to understand as many of these stations are remotely located and the towers generally become the highest structure in the locality.

A good station ground should be provided and the tower, housing, and fence should be securely bonded to the ground bus. The station ground, in average conditions, should consist of four 8-ft copperweld ground rods or equivalent, one placed in each corner of the tower and one 10-ft ground rod at the power line entrance. All ground wires should be No. 6 AWG copper as a minimum and the connections should be made with Underwriters Laboratory approved mechanical clamps.

The incoming power should have pellet type thyrite lightning arresters connected to each hot side on the load side of the fuses, while carbon gaps can be used on telephone or control circuits where there is no DC used and carbon gaps with suitable fuses where there is DC.

All coaxial lines should be bonded to the ground bus at their lowest point on the tower and all gas tanks, switch boxes, and other such accessories should be grounded.

Standby Power Generators

The installation of standby power generators at all remote repeater stations is a very worthwhile investment. Such an investment pays off during times of trouble, such as a power failure or the like when communications are most important.

Standby power generators can be provided which will go into action immediately upon the failure of the primary power and will continue to handle the load until the normal source of power is restored. The generators may be powered by gasoline, propane, or similar fuel.

The duty period of such generators depends upon the size of the fuel tank but normally a 55 gal tank is used for a gasoline installation and it will handle the load continuously for about 48 hours. Examples of these units appear in Fig. 39.

Repeater Station Housing

Some sort of housing will be required at the repeater stations. In some cases the communication equipment is housed separately from other equipment even though sufficient space is available. The reason for such an act is, of course, safety. For example, let us say a pipe line pumping station is damaged or destroyed then the communication equipment would still be intact and available for use at this critical time. Whereas if the equipment had been housed with the pumping equipment then both would have been incapicitated.

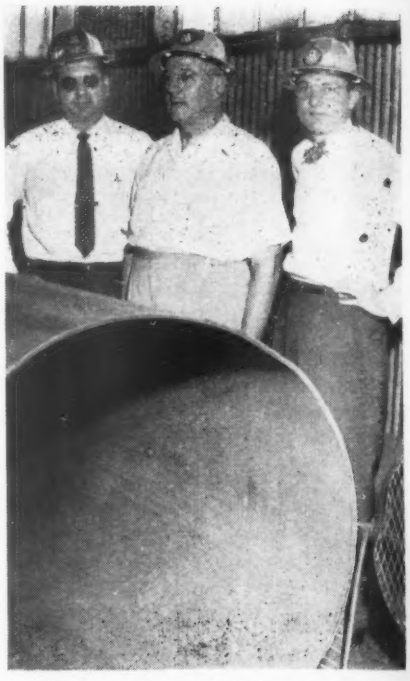
Usually this housing has taken the form of pre-fabricated steel houses or a concrete block house. At through repeater stations, where there is only RF equipment with the standby power units, the housing would be approximately 10 by 10 by 8-ft but they sometimes reach 12 by 14 by 8-ft when there is a large amount of telephone and multiplexing equipment.

In most areas the heat generated by the equipment plus the insulation of the building will keep it warm in the winter and exhaust fans or blowers will keep it within the temperature limitations during the remainder of the year. In areas where the winters are severe, however, auxiliary heaters may be required.

To keep curious visitors from interfering with the service, fences are usually placed around the house and tower. These fences generally provide about a 6 ft clearance around the 2 objects, as in Fig. 40.

All the aforementioned items go together to form a complete communication system as pictured in Fig. 22. The application engineering of these items requires a great deal of time and a lot of close coordination to place the system into operation in the shortest possible time.

Equipment manufacturers are prepared to offer the services of their application engineering and field service to any organization planning to use microwave in a communication system. Preliminary system designs can be made upon which budget estimates can be based and final designs prepared. Engineers with extensive field experience will be provided to coordinate the installation of all the necessary equipment. * * *



Officers of Consolidated Western Steel and Transcontinental Gas Pipe Line Corporation inspecting the new 36-in. pipe being built at Consolidated's Orange, Texas, plant. Officers are: Lee S. Cline, assistant to vice president of production, Consolidated; Tom P. Walker, president, Transcontinental, and Ralph W. Seely, vice president and general manager, Consolidated.

Big Pipe Built

A new dimension was added to the long distance overland transportation of natural gas and oil when U. S. Steel's Consolidated Western Steel Division started producing 36-in diameter pipe at its Orange plant.

Consolidated inaugurated the first mass tonnage production of this diameter pipe for long distance use in August. Its first order is for 50 miles of pipe for Transcontinental Gas Pipe Corporation of Houston, Texas.

This 36-in. pipe offers a significant step-up in carrying capacity from 30-in. pipe, the maximum size generally in use. There is only one other gas transmission system using pipe larger than 30-in. and this is 34-in., also produced by Consolidated.

Consolidated officials pointed out that the 36-in. pipe will permit the transmission of gas and oil in unprecedented volume, with resultant service and sales benefits for the carrier. A secondary use envisioned for the new-dimension pipe is the storage of petroleum products in areas adjacent to markets.

Start of production on the 36-in., expanded API 5LX52 pipe came after a long period of engineering study. Transcontinental has the giant pipes earmarked for installation near Tylertown, Mississippi and Billingsly, Alabama.

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"Caterpillar equipment," reports R. M. Jones, superintendent on the job, "will last longer with less maintenance than any other equipment I've ever used."

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Good Methods and Procedures in Warehousing†

- means parts are available when needed
- means economy through quantity purchases
- means standardized material control and accounting
- provides strategic location of spare units for emergencies

J. A. HATFIELD

THE operation and maintenance of Plantation's 43 pump stations and delivery terminals, 3 tank farms, and 2050 miles of trunk lines are apportioned to 3 field divisions. These divisions are operating organizations under the supervision of division superintendens. The division superintendent—through his principal operating, maintenance, and service supervisors — is directly responsible to the vice presidents-operations for all company activities within his division.

Division offices are located at Baton Rouge, Louisiana; Bremen, Georgia, and Gastonia, North Carolina. Warehousing facilities and stock, for the most part, are concentrated at these 3 division headquarters; however, an adequate supply of parts and materials is stocked at each station and terminal to supply the demand for a minimum period of 30 days. The value of warehouse stocks at the November 30, 1953, inventory was $963,324, which included $258,404 in line pipe. The total inventory amounted to 1.2 per cent of Plantation's investment in plant, or $390.93 per mile of trunk pipe line. These stocks are maintained almost exclusively for the operation and maintenance of the system.

Repair Parts

In order to protect operations, the company holds to a policy of stocking repair parts for machinery, and pipe and pipe fittings for line repairs. Repair parts are stocked for pumps, motors, meters, valves, switchgear, and other electrical control equipment. All of this equipment is standardized throughout the system. The amount of stock to be maintained in the warehouses has been determined by experience in turnover and time required for delivery from suppliers.

Normally, a 60-day supply of stock is maintained. For example, experience has shown that 64 idler gears, 64 shaft bearings, and 16 shafts are used in meter repairs in a 60-day period in the in the western division. Delivery time of these parts from the supplier is approximately 90 days.

Therefore, a minimum stock of these parts for a 60-day period would be 64 idler gears, 64 shaft bearings, and 16 shafts. The normal demand for these parts and the time required for delivery of them from the supplier make it feasible to carry a maximum stock of 128 idler gears, 128 shaft bearings, and 32 shafts. Another example would be TK‡ relays for main-line motor electrical controls. Experience shows an average of one TK relay replaced each month in the western division. A 45-day period is required to accomplish factory repairs to these relays. Therefore, a minimum stock of TK relays is 2, and a maximum stock is 3.

Spare Parts

For practical purposes, an adequate supply of spare parts for machinery is held in the custody of the division foreman so that they may proceed to the job without the necessity of their contacting the warehouse for parts. At the completion of a repair job the foreman renders an accounting to the warehouse for parts used, and at the same time turns in to the warehouse the used parts recovered in the course of the job.

In addition to this parts' stocking arrangement ,the company has available, at strategic points on the system, spare units of essential machinery that can be quickly and efficiently installed whenever emergency replacement of machinery has become necessary.

Warehouse System

Economy and convenience can be considered the principal reasons for the use of the operating warehouse system. The acquisition of quantities is, of course, advantageous usually from the standpoint of cost. The availability of materials required is essential to the operation of this or any other system. On the other hand, where minor items can be acquired locally, it is generally the policy to purchase in this manner. This not only proves to be more economical, but serves the company well in the furtherance of good public relations.

It is the policy of the company to limit local purchases to a total of $25

The Author

J. A. Hatfield is a division superintendent for Plantation Pipe Line Company. A graduate of University of Georgia executive development program, Hatfield was formerly with Lago Oil and Transport Company He transferred to Plantation in early 1942, in charge of pumping station at Silver Run, Alabama. He was made division superintendent of the company's eastern division in January, 1946 and promoted to division superintendent of the largest division in early 1947, with headquarters in Baton Rouge, Louisiana. For approximately 18 months in 1950-1951, he was in charge of the company's largest construction program in the western division, building approximately 450 miles of 18-in. line tank farms, and pumping stations. On June 1, 1954 he was given job rotational training assignment for one year in the company's executive offices in Atlanta, Georgia as assistant to the vice president in charge of operations.

†Presented at API Products Pipe Line Conference, Philadelphia, Pennsylvania, May 10, 1954.

‡TK = timing relay.

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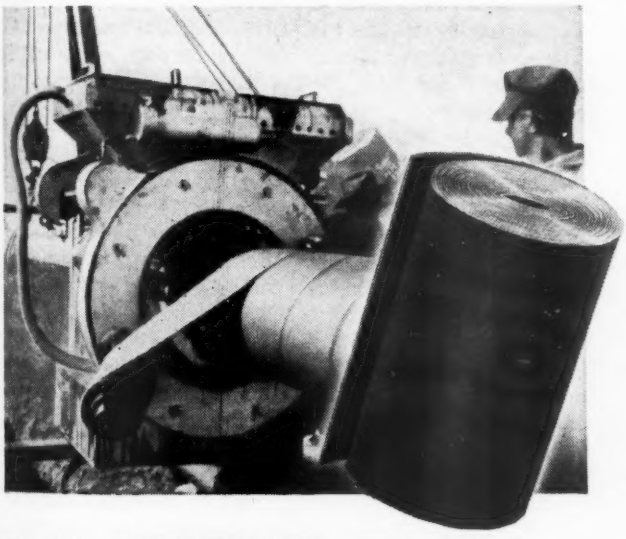

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XUM

Meter parts storage bin in division warehouse. On bottom shelf are complete rotor assemblies, bearing plates, and rotors. Other shelves contain meter component parts, such as registers and rotor plates on second shelf; bearings, control gears on third shelf, and idler gears, vane gears, shafts, and vanes on fourth shelf.

Right, pump parts storage bins in division warehouse. First section (left foreground) contains complete mechanical seals and repair parts; second upright section holds repair parts for 3-stage centrifugal pumps, and third upright section holds repair parts for single-stage pumps.

per month at each station or terminal. Even though there are these limitations to the practice of purchasing materials locally, the company policy is such that, in the event of an emergency or to meet a construction schedule, the materials may be acquired locally in the quantities required. This is merely another application of the overall policy which simply stated is "keep 'em pumping."

It is well to point out, however, that these local purchases are controlled from the standpoint of uniform quality and standards. Paint specifications, for example, have been adopted — first, with the idea of acquiring the most suitable and economical product and, second, with the consideration of supply, which is governed by the fact that paints of the brand that meet the company's requirements are available for local purchase at all points on the system.

Other supplies that are not carried in warehouse stock, but which are acquired in quantities not available locally, are purchased and shipped directly to the station or terminal and charged to the proper maintenance or operation. These materials include:

- Product-filtering supplies
- Lubricants
- Air filters
- Lamps
- Sanitary supplies
- Wiping rags
- Paints
- Small tools
- Caustic
- Scraper parts

The acquisition of materials for storehouse stock, as well as directly for operation and maintenance, begins with the preparation of purchase requisitions in the field. Each requisition lists a complete description of each item or all items, as the case may be — indicating, if possible, the supplier and approximate cost, as well as other facts such as the use for the material; i.e., whether for use on "authority for expenditure" (AFE), station operation, or repairs, and the time needed, and the means of transportation.

Requisitions are submitted to the division office, where the warehouseman deletes any materials that are in stock and indicates that these will be shipped from the local warehouse. The requisition is then approved by the division superintendent and forwarded to the purchasing agent in Atlanta, Georgia. After executive approval, usually by the vice president-operations, the requisition constitutes authority for the purchasing agent to issue a purchase order or orders, as the case may be.

The purchase order presents all essential data concerning the material, manner of shipment, and the date required. Also each purchase order shows the manner in which the material is to be tagged for use at destination. This tagging may indicate storehouse stock, station operation, or other pertinent facts as shown originally on the requisition. Copies of the purchase order are then sent to the accounting and engineering departments, the division office, and the receiving point.

When materials are delivered to the destination, and have been checked against the purchase order and found in good order, a "material received report" is prepared, the original and a copy of which are transmitted to the purchasing department; one copy is sent to the division office, and the remaining held for the local file. The purchasing department holds the "material received report" in suspense with the open purchase order until invoiced

by the supplier. If the invoice conforms to the purchase order and to the materials received, the original of both the invoice and the "material received report" is forwarded to the accounting department for processing. The accounting department will then catalogue the invoice with attached "material received report" for payment after all data have been reviewed, comptometered, discounts taken, and sales or use taxes calculated. When date of payment arrives, the invoice is vouchered, and a check is drawn and forwarded to the supplier. Thereafter the "material received report" is removed and field under the local station or storehouse records in the accounting department.

Purchases for warehouse stocks follow this procedure except that, in addition to the tagging "storehouse stock," the assignment of a stock number for each item is required prior to the processing of the invoice and "material received report" by the accounting department.

A catalogue of materials prepared by the accounting department, with the assistance of the warehousemen, is printed on the tabulating machine in the accounting department, and is made available to each warehouseman and station. Materials in this catalogue are classified roughly as "electrical" and "other materials." Sub-classifications are carried under such headings as parts, line pipe, sanitary supplies, and valves. Each classification is indicated by a control stock number, and each individual item under this control is further identified by an item number. For example, parts for an 8-in. by 10-in. 3-stage pump appear under classification No. 314, and the first stage impeller is identified as the item No. 25. The classification of sanitary supplies is controlled under No. 351, and the items thereunder listed accordingly.

In conformity with Interstate Commerce Commission procedure, the carrier allocates the overhead applicable to the division warehouses to the various accounts as a proration of the cost of materials issued. Included in this proration of material-store expenses are the salaries and expenses of the warehouse personnel. The percentage of this overhead, applied to materials issued, varies according to the turnover of stocks within a given period; however, it averages from 8 to 10 per cent.

The operating warehouses are a functional unit of the division organization, and are under the supervision of the division chief clerk. The warehouse is staffed by a senior warehouse clerk, who is assisted by one or two clerks — depending on the volume of turnover in stocks and on the differ-

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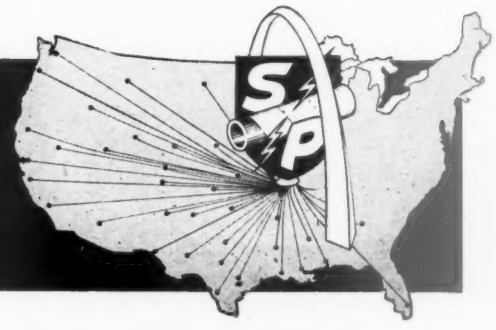

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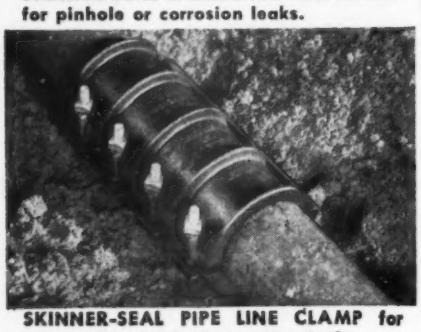

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ences on local transportation problems. The purchasing agent has an assistant and a staff of two clerks and two stenographers. The accounting department has two full-time clerks assigned to the materials section, and these are supplemented by the stenographic forces and the services of the tabulating-machine department. It is the duty of the accounting department to inventory each year the storehouse stocks of the entire system.

Under major construction programs, the function of warehousing becomes separate and distinct from that of operations. Personnel are specifically assigned to construction, and temporary warehousing facilities are installed. All records such as requisitions, purchase orders, and material tickets are identified by a special series of numbers, and are filed accordingly.

Requisitions originate with the engineering department, following the design of the proposed facilities. In conjunction with the accounting department, a "tagging" system is devised which indicates, for each item requisitioned, the purpose it is to serve. This description dovetails with the accounting code applicable to individual units and sub-units of property.

Purchase orders issued in accordance with the authorized requisitions also carry this tagging feature. Copies of the purchase order are distributed to all concerned, including the warehouseman at the job site.

As construction materials are received, the "material received reports" are prepared in the prescribed manner, and the "tagging" is also listed thereon. These material tickets are then matched with invoices from the purchasing department and subsequently transmitted to accounting. The accounting department, in vouchering the invoice, has available the distribution shown on the material tickets. Many suppliers transcribe the tagging from the purchase order to the invoice itself.

Locally, on the job site, a card record is maintained on the materials received. Postings on these cards include the reference to the material ticket and the use of the material in construction. It is presumed, under this system, that the materials will be used according to the tagging. In the event there is a change of plans, this is recorded on a transfer report isued by the warehouseman.

At the close of the job materials remaining on a standard form as surplus, and thereon is included the reference to the material ticket on which each item was originally received on the job site. This listing of surplus is submitted to the operating warehouseman, the purchasing department, and the accounting department. The operating warehouseman will earmark whichever items are carried for warehouse stock. The purchasing department will try to allocate materials to other jobs, to stock, or will attempt to dispose of the surplus otherwise. Material transfers subsequently issued which account for this surplus are then processed by the accounting department, and the project is relieved by these materials.

A standardized material-control and accounting system is used by the three division warehouses. This system is coordinated by the accounting and purchasing departments in the Atlantic office. Final accounting is accomplished, in the accounting department, from information submitted by the field.

Material Control

In the division warehouses there are primarily seven standard records used in material control. Following is a description of each of these records and their function in controlling and accounting for material:

1. Purchase requisition: This record is used as the first step in the acquisition of stock items. As mentioned hereinbefore, it is also used for material to be charged directly to a location or job. The requisition specifies the quantity and a detailed description of the material ordered.

2. Catalogue of material and supplies: The catalogue of material and supplies is a guide list for all materials in storehouse stock insofar as identifying stock numbers and standardized descriptions are concerned. The materials, including operating supplies, are classified in the following two major groups: General (including parts) and electrical.

These divisions are arbitrary, but practical and self-explanatory. Grouped under "general" are all materials, including parts, with the exception of those classified as "electrical." For reference, there is an alphabetical listing of both "general" and "electrical" classifications. All identical materials throughout the system bear the same stock numbers. For example: "pipe ½-in. galvanized" always appears under stock No. 286-33. All materials and supplies are to be described on material tickets and on other records to conform with the listing in the catalogue. The ready identification of all materials is made possible by the use of the assigned stock number. Material in storehouse stock is to be identified and segregated so that the stock number for each item may be readily known. If an item received for storehouse stock does not appear on the listing, a stock number will be assigned by the accounting department in response to a memorandum or teletype message requesting same.

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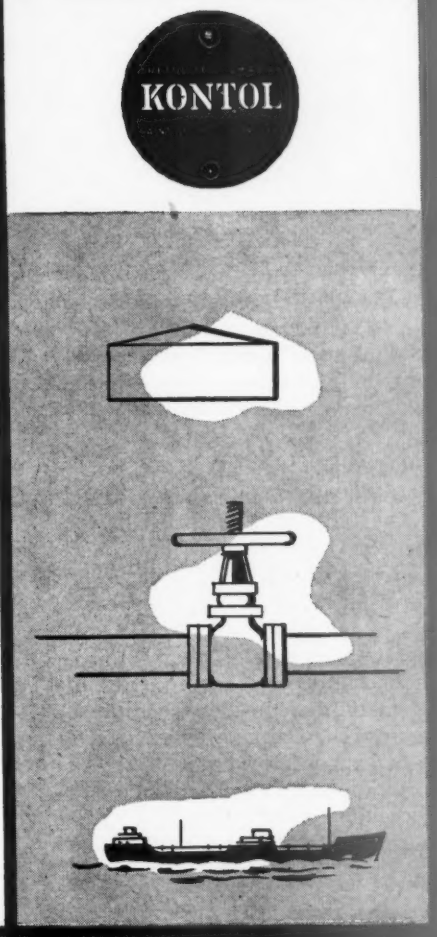

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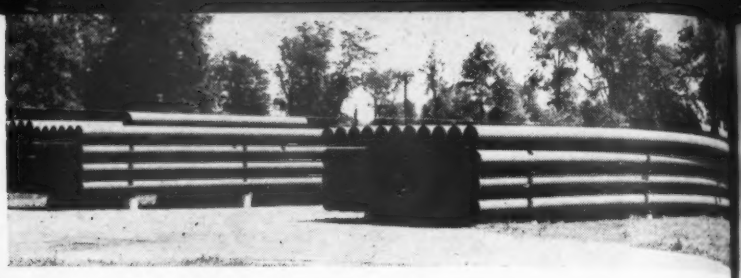

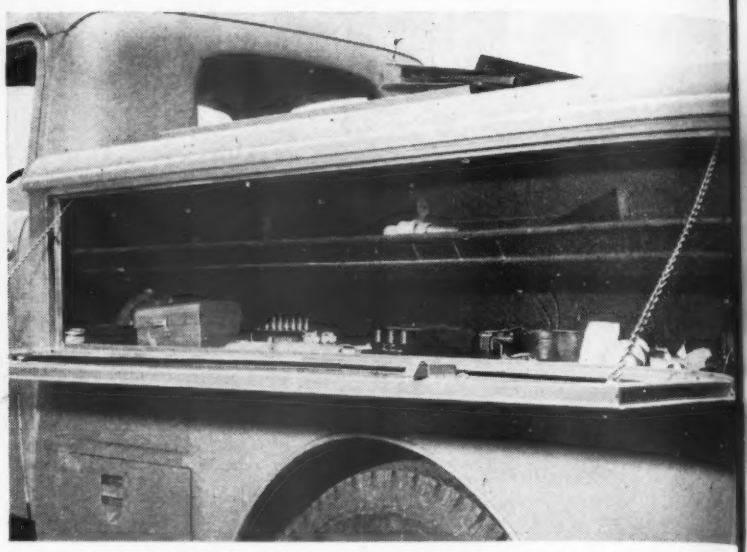

Valves and valve parts storage bins contain small valves and repaid parts for large plug valves. Top sections contain the small valves while lower section shows segment gears and other parts. Upper right, pipe storage racks at division warehouse, where 18 and 20-in. seamless steel line pipe and 22-in. seamless steel thin wall pipe casing is stored carefully on racks. Lower right, electricians ¾-ton utility service truck contains all needed equipment, including control switches, circuit breakers, transformers, coils, oil circuit breaker replacement parts, and parts for electrical control mechanisms.

3. "Material received report" (MRR): All materials acquired under a purchase order or bought locally for construction projects or storehouse stock are recorded in quadruplicate on this form. It should be noted, however, that when purchases are made of operating supplies such as soap, cleansers, light bulbs, and similar items in small quantities, those expenditures, when included in an individual's monthly expense statement, need be supported only by the receipted sales ticket. In the spaces provided, the following information is inserted on the MRR:

1. Name of person or firm from which material is purchased.

2. Station or storehouse name.

3. Date form is prepared.

4. Local station or storehouse

5. Name of "storehouse" receiving goods, "station supplies," "AFE," etc.

6. Means of transportation; i.e. via freight, express, or parcel post, and way-bill number.

7. Transportation, amount paid, if collect; otherwise indicate "prepaid."

8. Purchase order number.

9. Description of the material, stock number (if brought into storehouse), grade, and quantity.

10. Date material is received.

11. Signature of station chief, storehouseman, or individual in charge of material.

An MRR is prepared for every shipment of goods purchased, and all goods so received are to be listed thereon. When this form has been properly signed, the original and one copy are forwarded immediately to the purchasing department; one copy to the division office; and one copy retained for local station records. This form is never prepared to acknowledge services performed by some concern such as "cleaning felts" or "repairs to equipment No. 51."

When gasoline, lubricants, and other supplies are acquired and placed in the vehicle, the service-station invoice is sufficient evidence of purchase and receipt, and no material ticket need be issued. The company equipment number is to appear on this invoice. If gasoline, oils, and similar items are acquired at the division storehouse, however, such purchases are recorded on the MRR and brought into stock in the manner prescribed.

Local cash purchases of materials that are to be accounted for on expense statements need not be recorded on an MRR unless the material is acquired for an AFE. Whenever an MRR is prepared under these circumstances, no purchase order number appears on the ticket, and a notation is inserted to read, in effect, that the invoice will be attached to an individual's monthly expense statement. The purchaser retains these invoices and whatever MRR's are required; then he submits all items attached to his monthly expense statement.

Discrepancies between quantities received and those designated on the purchase order or invoice, if any, are to be noted on the MRR. Also full details are shown in case material has reached destination in a damaged condition and the transportation company's representative is to acknowledge this damage on the freight or express bill. Under these conditions the MRR's are forwarded in the usual manner to the purchasing department, accompanied by the transportation bill.

Such material as the following, when received in quantities for local station consumption, is shown to "station supplies" instead of to "storehouse":

Air filters	Paper towels
Caustic	Small tools
Flashlight batteries	Soap
	Strainer felts
Hay (excelsior)	Toilet paper
Ice	Towels
Light bulbs	Washing powder
Lubricants	Waste and wiping
Office supplies	

If any of the supplies are acquired for some specific job, information to that effect would appear on the MRR. For example, some of these items might be used in the course of a job, such as:

AFE 2100 "Replacing control lines," or

AFE 2105 "Rearrange terminal lines."

4. "Material used report" (MUR): All materials issued from warehouse stocks to the local station and/or office for construction, operation, or maintenance are recorded on this form in duplicate. The original is forwarded to the purchasing department, and the copy is for the division office. The use of this form is limited to recording issues of materials from storehouse stock under the foregoing conditions. The following information is shown:

1. Storehouse stock.
2. Location of storehouse.
3. Date ticket is prepared.
4. Local storehouse MUR number.
5. Use for material (AFE, station operations).
6. Description of material with stock number, grade, and quantity in catalogue.
7. Date of transaction (this refers to date material was actually issued to the job).
8. Signature of individual in charge of storehouse.

Information pertaining to use of materials is very specific and exact — particularly insofar as the features of construction projects are concerned. Whenever material is issued to replace property in service such as pipe and fittings, a reference is made on the MUR indicating the replacement as well as the material ticket which removes the salvaged materials. Always, when a construction project is concerned, the AFE number appears on the ticket with a description of the specific use of the material.

5. "Material transferred report" (MTR): This form is issued as a means of recording the following transactions:

1. Transfers of materials to other storehouses.
2. Transfers of materials to other parties (sales).
3. Bringing into storehouse material removed from carrier property.
4. Return to storehouse of materials originally charged to operations, maintenance, repairs, and AFE's.
5. Reclassification of materials.
6. Shipments to suppliers and outside shops (an MTR is issued when shipping out, and another if material is returned).

The MTR is made out in quadruplicate on each of the aforedescribed occasions. The original and a copy should be forwarded to the purchasing department, one copy to the division office, and one copy should be retained for local station records. In all instances the following data are filled in:

1. Source from which material is being transferred: AFE; or carrier property (state exact feature of property such as motor No. 1, drain lines,

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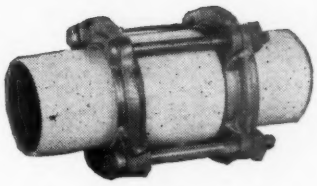
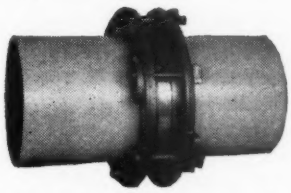
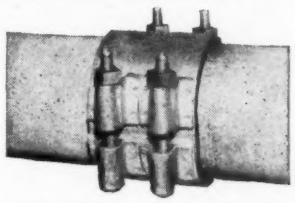


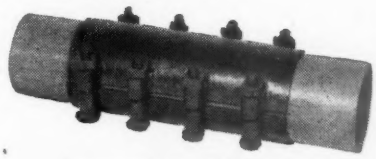
For leaks through threads of screw collars. *Collar Clamps,* Styles 4 and 41.



For leaks and holes in run of pipe. *Band Clamp,* Style 77B.



For repairing leaks in asbestos cement pipe. *Hydrepair* Clamp,* Style 179.



For repairing pitholes and longitudinal splits. *Split Repair Clamp,* Style 79B.

*HYDREPAIR is a trademark of Dresser Manufacturing Division.

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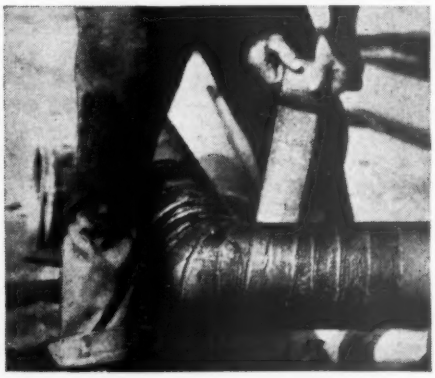

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section number, pump-station lights); or storehouse; or use in station, section, tank farm, or terminal.

2. Station or storehouse location.
3. The date form is prepared.
4. Local station or storehouse MTR number.
5. Storehouse, individual, or firm receiving material.
6. Date on which material was originally received or installed. (If "material receiving record" cannot be located, this date should be estimated.)
7. Method of transportation (company equipment number, freight, express).
8. Transportation charges paid.
9. Reference to number of receiving record and purchase order or which material was originally acquired.
10. Catalogue description of material, including stock number if storehouse is involved.
11. Signature of person in charge of material.

Three copies of the "receipt of transferred material" are prepared for every shipment to other storehouses, stations, and terminals.

Reclassification of material is prepared on the "material transferred report" for the purpose of revising records both locally and in the Atlantic office, so that all records agree as to the actual condition and type of material. This includes correction to stock numbers, grades, and specifications. For example, if a plug valve received into stock as Fig. 1985 proved later to be Fig. 1989, this form should be issued to make the correction.

6. "Receipt of transferred material report" (RTR): Whenever a "material transferred report" is issued to record the shipment of material to another point on the system, three additional copies of the information are prepared on the "receipt of transferred material." One copy of this receipt accompanies the shipment, and the other two are mailed to the destination. As the material is received at destination, the quantities, specifications, and stock numbers are checked against the "receipt of transferred material," and discrepancies, if any, noted thereon. The receiving station inserts its local RTR number on the three copies, and draws a line through the number already appearing on the ticket as prepared at the point of issue. The three copies are then signed by the station chief; one copy is forwarded to the purchasing department, one to the division office, and one is retained for local files. The receiving station inserts on the ticket full information as to the use or disposal of the material. This procedure records the complete transaction with the typing of only one material ticket, as the receiving storehouse uses the prepared

(Below) Wheel-type 215 Trenchliner® opens cross-country trench at speed up to 18 feet per minute. It digs 13 to 31 inches wide, 6 feet deep. Has standard tractor crawlers, with 18-inch treads, lug-type shoes . . . standard-make 55 h.p. diesel engine, and many other features developed for the oil field. Parsons line includes 3 other models, wheel and ladder-types on crawlers.

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copy of the "receipt of transferred material" as its receiving report.

Whenever materials are sent to suppliers or shops, one copy of this "receipt of transferred material" is transmitted as a bill-of-lading in order to enable outside concerns to check materials and quantities.

7. Storehouse ledger cards (post index): All warehouse stock material is catalogued on post-index rapid reference file, card size 9¼ in. by 8 in., with center fold to make inserted card 5 in. by 8 in. Cards are so constructed that each side is printed in order to utilize front and back for posting. The card carries space headings to list all all types of material records under separate colums such as MRR, MUR, RTR, MTR, date space for date of each individual record, and space for remarks pertaining to those records. The remark column is used primarily for showing if outgoing material is used as general operating supply, repairs to carrier equipment, or new installation. For incoming material, this space shows either manufacturer's name or our purchase order number. Current balances are kept on these cards by use of three columns headed "receipts," "issues," and "balance."

By daily posting of material records of receipts and disbursements, a current inventory of all materials is shown in balance columns. Heading of cards gives description of material, grade, maximum and minimum amounts to be carried as warehouse stock, and location of material as placed in different sections of our storage facilities. One post-index cabinet is sufficient for approximately 1000 cards, and is kept as part of current file for filing cards which have been completely posted. These cards, after a normal length of time, are removed and filed according to numerical stock-control number in our dead file.

Plantation Pipe Line Company's cataloguing of material is done alphabetically and numerically with a spare-parts section included for all types of equipment and instruments. Within the spare-parts group, for each individual piece of equipment or instruments, the parts are set up alphabetically with separate control numbers for each group. Controller parts would carry control No. 250; individual parts would carry No. 250-1, 250-2, alphabetically. Pump parts for one type of pump would carry control No. 266, and individual parts would be set up alphabetically with No. 1-2-3, as above.

Certain groups of general supplies, all used primarily for one type of work, are included alphabetically under one control number, such as automotive supplies (excluding gas and oil) under stock-control No. 2. Under control No. 2 would be listed anti-freeze as possibly No. 2-1; batteries as No. 2-2; tires, with each size being given a separate number, as No. 2-3, 2-4, 2-5. Sanitary supplies are grouped under one control number, vis., No. 351; and all sanitary supplies are set up alphabetically under No. 351-1, 351-2. When post-index cards are correctly in the file, stock-control No. 1 is first, and is followed numerically by others.

All materials are tagged with their description and stock number in material bins, and bin numbers show on the file card. This gives a cross-reference in case materials, especially small parts, are hard to identify. By having either stock numbers or description, the materal can be located in storage by the number of the bin.

Conclusion

Plantation Pipe Line Company has found that its warehousing facilities are necessary for assured minimum operating interruptions, economy, and convenience. These warehousing operations should not be construed as a chain of hardware stores along the pipe-line route; i.e., necessities are stored, and these are kept to minimum inventories. These warehouses have been a great asset in the succesful operation and maintenance of the system.

* * *

There's no substitute for the skill of an experienced welder. But his speed can be increased and his percentage of reject welds lowered by equipping him with an H & M Pipe Cutting and Beveling Machine. The semi-automatic H & M eliminates human error in all cutting and beveling operations. The horseshoe-shaped gear of the new lightweight H & M slips easily over the pipe . . . the spring-tension chains snap the machine securely into place . . . the torch arm adjusts to the desired bevel . . . a few turns on the hand-crank lead the torch completely around the pipe. The precision of a Swiss watch . . . the ruggedness of a bulldozer — that's the H & M Pipe Cutting and Beveling Machine now 40% lighter and offered in five sizes to fit 4" to 36" pipe.

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Compressor Plant Trouble-Shooting

D. R. ARNOLD

COMPRESSOR plant trouble-shooting can be more often accomplished the easy way if the original installation is made with two main considerations in mind. First, the plant should have been originally designed with sufficient indicating equipment to simplify future trouble-shooting. Second, this indicating equipment should be so installed that undue variation will be immediately noticed.

It is easy to leave out test and drain connections in the original installation, which can materially complicate the task of future trouble-shooting. A great many installations are inadequate in this regard. The pipe, valves, and fittings should be installed so that any trouble can be easily located without having to shut down or hot tap to install test connections.

In other words, when an installation is planned, one should consider what he would do if it does not work properly instead of just assuming it will. These considerations are equally important on field installations where a line or two is changed and perhaps the entire operation is thereby altered.

In general, whenever the temperature of gas, water, or lube oil is materially changed in a cooler, heater, by compression, or by blending, a thermometer well should be installed. Sometimes, the only way to determine flow rates is to use relative temperatures. An example of this is when the total flow through a line is known, but a temperature controlled by-pass valve directs some of the fluid through a cooler and some is by-passed to the cooler discharge. The quantity of fluid actually cooled can only be determined by the use of relative temperatures.

An orifice flange can sometimes be placed in a line during construction and later prove to be a trouble-shooting lifesaver. If a continued pressure drop is not detrimental, an orifice plate can be installed but no meter connected. In other instances, the line can easily be shut down and a plate installed if the flanges and taps were originally provided.

The Author

David R. Arnold is with Guy T. Martin and Company in charge of manufactured products. He is a graduate of California Institute of Technology and has a MA in business administration from Stanford University. Arnold was formerly associated with the Superior Oil Company in Los Angeles as assistant superintendent of the manufacturing and sales department. He was general chairman of the 1953 California Natural Gasoline Association Fall meeting.

Locations for pressure gages are less easily overlooked, but they can be just as important. As in the case of temperatures, a pressure gage connection should generally be provided each time the pressure changes appreciably, such as by compression or pumping, or by passing through a cooler, heater, or a long pipe line of critical size. Drains and sample connections are likewise important but are less easily overlooked.

This indicating equipment should be situated in such a way that undue variation will be immediately noticed. Many times, red marks painted or otherwise placed on pressure gages and dial thermometers will offer an immediate indicator that something is wrong. If each of the operating personnel is aware of these various danger signs, one has gone a long way in providing for compressor plant trouble-shooting — the easy way.

The various service representatives of the compressor manufacturers have developed individual procedures to simplify their everyday trouble-shooting and each attach particular importance to certain phases of the original installation and later operation. They have their own do's and dont's that usually are not included in the instruction books. As it is their job to develop compressor plant trouble-shooting—the easy way, they have been consulted in the preparation of this paper.

The balance of this discussion has been divided into sections covering the various phases or services within a compressor plant. Comments pertaining to four cycle and two cycle operation will be intermingled but it is hoped not to a confusing extent.

Process Gas System

The first to be discussed is the process gas system. It is unnecessary to say that efficient scrubbers are of utmost importance on the plant suction and on interstage gas after being cooled.

If one has occasion to construct any suction compressor cylinder volume bottles, it is a good plan to extend all cylinder stub connections up through the bottle about two inches. Any small liquid carry-over from the scrubber can thereby be caught and a drain valve on the bottom of the bottle will allow you to maintain a check on the scrubber efficiency. Of course, a temperature reduction in the line between the scrubber and the bottle can cause liquids to be formed even though the scrubber is performing satisfactorily, but this is a way to determine the quality of the gas going to the compressor cylinders.

Any time welded piping is added or changed, it should be thoroughly cleaned by pounding with a hammer and by blowing out if possible. If there is any chance welding slag or other foreign material can get into the compressor cylinders, it is a good idea to install suction screens temporarily as a safeguard for the cylinders.

Pressure gages should be installed on the suction and discharge of each stage of compression. The pressure drops across the intercoolers can there-

FIG. 1. Checking compressor cylinder valve leakage.

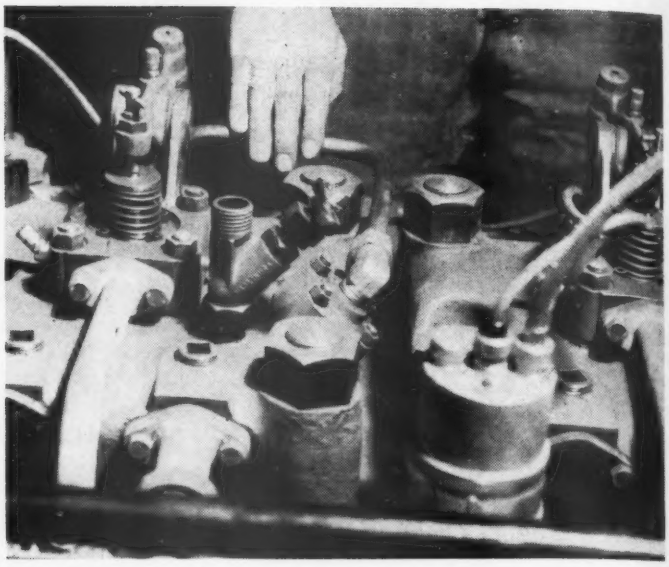

FIG. 2. Checking air starting check valve leakage.

by be watched. If the plant is operated at fairly constant suction and discharge pressures, red marks on the gages showing normal operating pressures, as mentioned before, will aid in quickly spotting trouble. Thermometer wells should be installed on the suction to each stage and the discharge from each cylinder. Dial thermometers are particularly useful in this regard.

Variation of the interstage pressure, with a constant suction and discharge, indicates a bad cylinder. If the interstage pressure increases, the high pressure cylinder is not taking the gas away fast enough. Conversely, if it decreases, the low pressure cylinder is at fault. If the gas discharge temperature from one cylinder is 20 to 50 deg hotter than that from another cylinder performing the same service, its operation is faulty. Neither of these procedures indicate what is wrong within the cylinder. The trouble can be a bad suction or discharge valve, or it can be leaky compressor cylinder piston rings.

Ordinarily, a leaky suction valve becomes heated and a leaky discharge valve transmits heat to the suction valve directly above it. In this manner, one can determine that either the suction or discharge valve is bad in a certain end of a cylinder, but not which valve. A quick test to determine which valve is faulty can be made by relieving the gas pressure on the cylinder and removing the indicator plugs. The gas is then cracked back through the discharge. A little gas leakage through the discharge valves is ordinary, but any great amount immediately locates the bad one. By the process of elimination, one can therefore determine if the trouble is in the suction valve.

A similar test can be used to locate leaky compressor cylinder piston rings. After relieving the gas pressure in the cylinder, remove an outer and discharge valve and replace the valve cover. Remove the frame end indicator plug, bleed the discharge pressure back slowly, and check for blow back through the rings.

Another good check to determine if a compressor cylinder valve is leaking badly is to immerse the assembled valve in cleaning solvent as shown in Fig. 1. If the valve holds the solvent without excessive leakage, it can be assumed that it is reasonably gas tight.

Carbonizing

At one time or another, most plant operators have been confronted with the carbonizing of suction or discharge valves or lead lines to and from a compressor. This, of course, most frequently happens when wet gas is being compressed in more than one stage without intercooling. It is difficult to know exactly how serious an effect this clogging has on the actual pressures within the cylinder.

A simple device can be made to measure these pressures. Six inches or a foot of pipe, capped at both ends, can be fitted with a pressure gage and a small inlet line on which is installed a check valve and a block valve. This device is then attached to an indicator plug hole on the compressor cylinder and the compressor is operated in its normal manner. If the check valve is installed with flow in the direction of the two-inch pipe, the gage will measure the maximum pressure ever reached within the cylinder. If the two-inch pipe contains high pressure gas and the check valve is reversed, the pressure will be reduced until the gage measures the minimum pressure ever reached within the cylinder.

A comparison of these two pressures with concurrent pressures down the line will quickly show the extent of this unwanted pressure drop and the need for shutting down and cleaning. On installations where this is a problem, valves should be installed on the indicator plug holes, and periodic checks made.

Lube Oil Systems

The second service in this discussion is the lubricating oil system. Most bearing manufacturers claim that 90 per cent of all bearing failures are caused from dirt. This is a never ending problem because every time the engine is overhauled there is a possibility that dirt will be admitted. There is a difference of opinion as to what type of pipe or tubing is the most satisfactory for lube oil lines. All agree that the usual black iron pipe is bad because the mill scale which is attached to the pipe can eventually work its way into the engine, clog the filter, and do damage within the crankcase.

Using galvanized pipe licks the mill scale problem but some contend that there is a tendency for the internal galvanizing to chip off and possibly cause crankcase damage. If the latter situation would ever occur, it would certainly be less serious than if black iron pipe were used. When welded pipe and fittings are installed, such as for direct lube oil cooling on a small installation, the welded spools can be pickled after fabrication. By this method, the mill scale is removed after all welding and fitting is completed.

Temperatures

The question of the most satisfactory lube oil temperature is a highly controversial one. Some operators whose experiences began with the slow speed, low output, type of engine are used to lube oil temperatures in the

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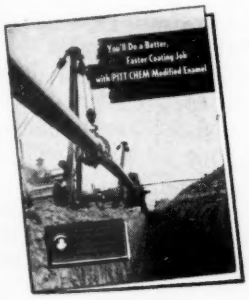

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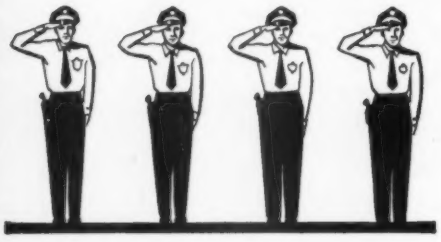

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order of 120 deg. Other persons favor high temperatures, in the order of 180 deg.

It is known that the correct selection of an operating lube oil temperature is an important one because incorrect temperatures will definitely cause crankase dilution, sludge, or varnish formations, any of which leads to high maintenance costs. Elevated lube oil temperatures also have the effect of substantially increasing the oxidation rate of the oil. A hot oil temperature of between 150 and 160 deg is generally considered the most desirable.

Low oil pressure can be caused by several different conditions, such as a low oil level, a broken pump, a dirty suction strainer, or a loose oil line connection. A chip or a piece of dirt might have become lodged underneath the seat of the pressure regulator. If tightening down on the spring does not raise the pressure, sometimes one can momentarily back off on the tension long enough to disengage the chip or piece of dirt. Then, when the spring is again tightened, the pressure should increase to its proper value.

A crankcase inspection will ordinarily locate the cause of low oil pressure. The appearance of babbitt metal squeezing out the sides of a bearing or evidences of heat are dead giveaways. Often, however, it is not easy to locate the bad bearing or oil leak. It is sometimes advantageous to put a little air pressure on the oil system when the crankcase doors are removed. A small amount of leakage is normal but a bad bearing will cause large quantities of air to escape. If the leakage is not excessive, the trouble is very likely in the pump.

Air Intake Systems

The third service to be considered is the air intake system. Cleanliness in the original installation is the one most important factor. The pipe and every welded joint should be thoroughly pounded to make certain that no mill scale, welding slag, or other foreign material is sticking to the piping which could later damage the engine. Of course the system should be thoroughly blown out with air before originally connecting to the engine.

An efficient air filter is ordinarily standard equipment on a new installation. It is a good idea to inspect frequently the inside of the blind end of the air intake manifold. Usually if sand or any other foreign material gets past the air intake filter, some of that material will lay in the bottom of the manifold, particularly in the blind end.

A manometer connection should be provided downstream of the air intake filter so that a pressure drop across the filter can be measured. When it becomes excessive, the filter should be cleaned. Each compressor manufacturer has a recommendation for the maximum permitted pressure drop. These recommendations should be followed closely. Ordinarily this will result in cleaning the filter about every four months. A fouled up air cleaner can greatly affect the engine's load carrying ability.

Starting Air Systems

The starting air system is the fourth item for consideration. Cleanliness should also be assured in the installation of the starting air piping. The lines should be hammered and blown out before connecting to make certain that no foreign material is present which could foul up the air starting mechanism.

Excessive water vapor in the starting air system can and does cause extensive damage within the engine. The reason for this is that the system is not used very often and, if water collects on the air valves or other mechanical parts, it has a long time to effect corrosion.

In extreme cases, some recommend that a drain pot be installed on the engine air header which would collect the water that has accumulated during each start and permit its removal. Some installations include a drier on the air that leaves the storage tank and even an oil atomizer whereby a small quantity of atomized lubricating oil is automatically introduced into the air stream.

The trouble shooting sequence for a faulty air starting system is simple. If the compressor cylinders are adequately unloaded, an inspection of the system's parts will ordinarily disclose the trouble. A good indication of air starting check valve leakage is to feel the piping near the valve. This is illustrated in Fig. 2. If the piping is hotter on one cylinder than another, it indicates leakage in that valve.

Engine Exhaust Systems

The fifth division of this article is the engine exhaust system. Some compressors, particularly the slow speed type, require that the muffler installation be made in such a way that the weight of the silencer and exhaust pipe is supported independently of the engine. If this is not done in these instances, vibration could result in breakage of the engine exhaust connection or manifold.

Each engine manufacturer has his own standards regarding the maximum allowable pressure drop in an exhaust system. It should be kept to a minimum by utilizing a short pipe run and

a silencer of adequate size and design as recommended by the manufacturer.

The extent to which pyrometer readings of exhaust temperatures should be used to determine the load balance in two cycle engines is certainly controversial. This will be covered under the general subject of the fuel gas system.

Cooling Water Systems

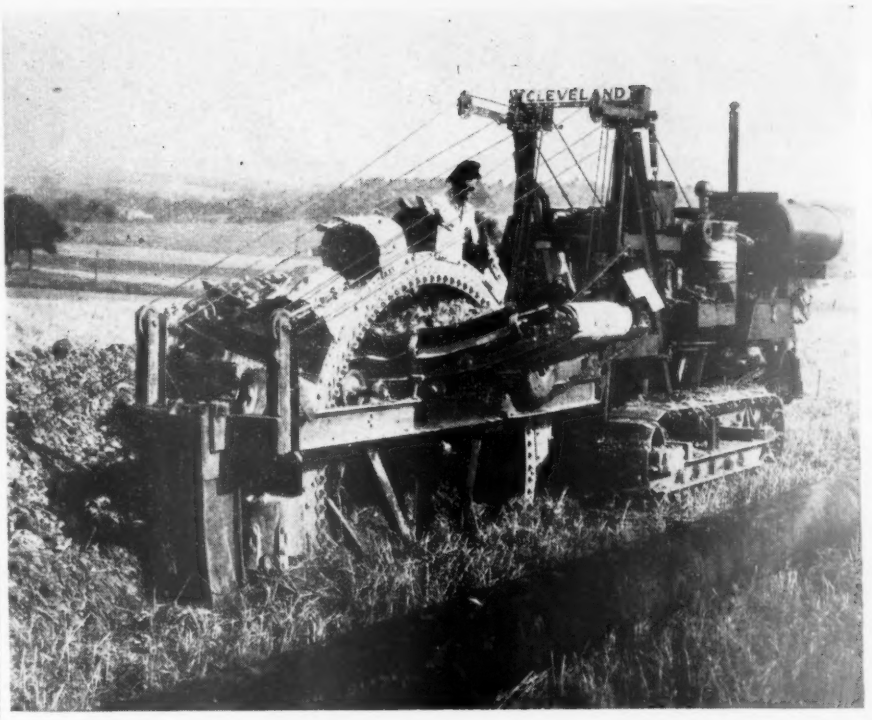
The sixth service to be discussed is the engine and compressor cylinder cooling water system. The subject of the selection of an engine jacket water operating temperature is a wide open one. The results of a great deal of experimentation in the last several years have certainly changed a lot of people's thinking. Without going into the pros and cons of boiling point cooling, it is sufficient to say that the upper temperature limit for engine water cooling is somewhere in excess of 212 deg and that the trend is definitely toward higher temperatures.

On the other hand, there are certain factors that place a definite lower limit on the engine jacket water temperature. For instance, it should always be higher than the temperature of the lubricating oil. In engines which have oil cooled pistons, this is particularly important because a lower jacket water temperature would have the effect of improperly reducing the clearance between the pistons and the cylinder. Most modern installations have a hot engine jacket water temperature in excess of 150 deg.

The factors governing the selection of the proper compressor cylinder cooling water temperature are entirely different. In general, a lower cooling water temperature results in less horsepower being required for compression. The reason for this is that the tendency to heat the gas being compressed is thereby reduced. On the other hand, when compressing "wet" gas, a low cooling water temperature is undesirable because it causes condensation of some of the heavier hdyrocarbons within the compressor cylinder. This causes some of the cylinder lubrication to be washed away and can cause a serious damage within the compressor cylinder. The cooling water temperature in this instance should ordinarily be in excess of 150 deg.

The necessity for cooling compressor cylinders with water varies with compression ratio. For low ratios, the trend is definitely toward air cooled cylinders. Sometimes, adequate cooling can be obtained by filling the water jackets with kerosene and relying only on natural radiation.

As different cylinders on the same engine have different cooling water requirements, a throttling valve should



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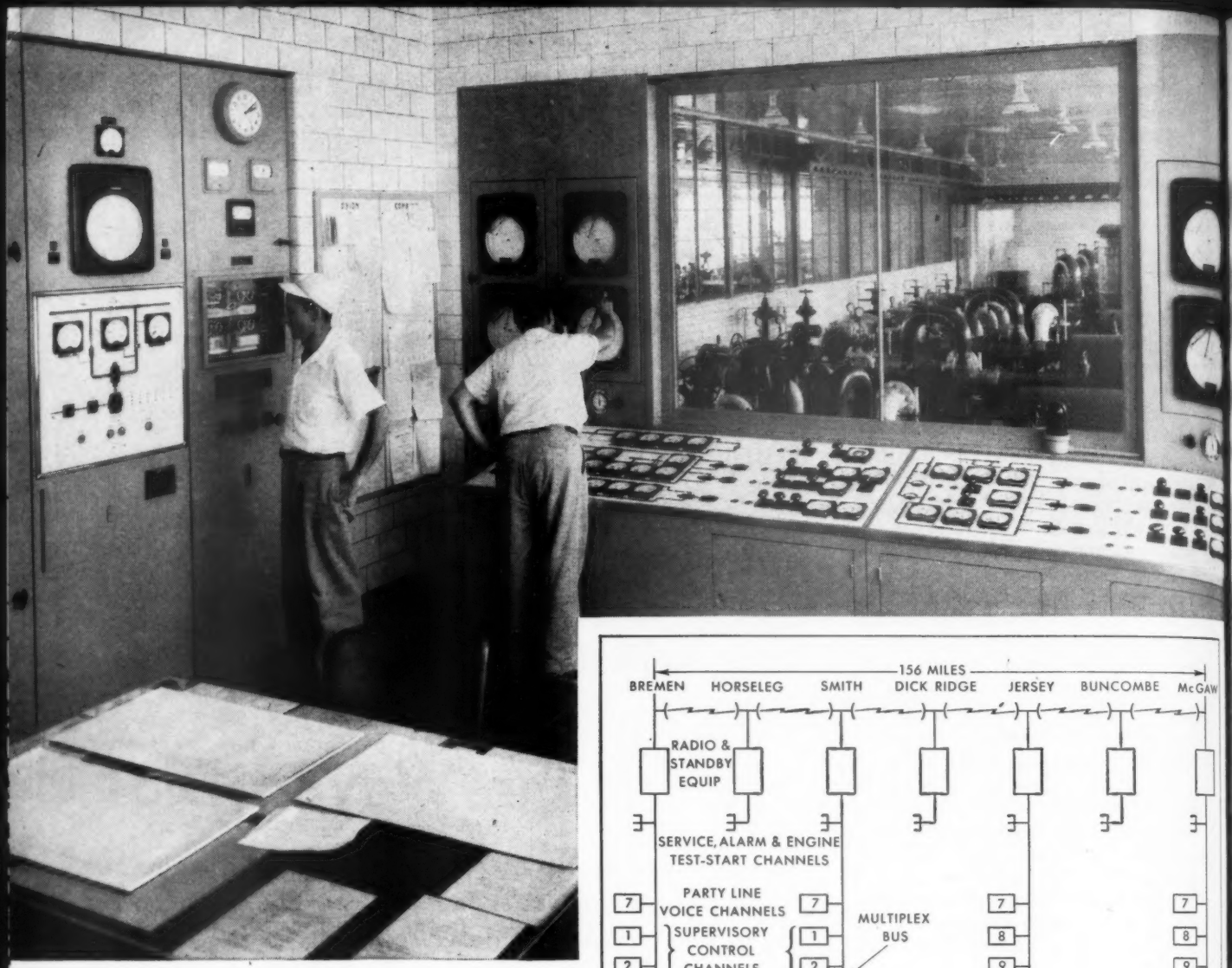

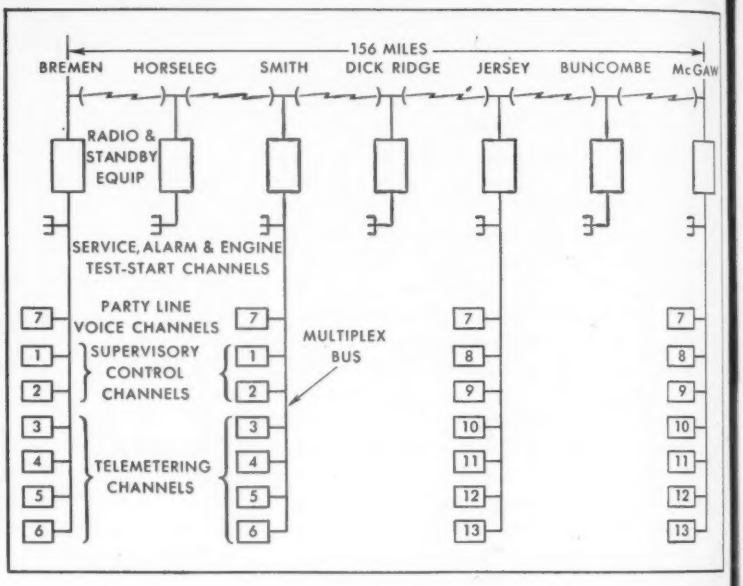

This is the Bremen Station central control room. Supervisory control for Smith booster station is shown at left. All meter and other panel indications are received over microwave. A diagram of the functions provided over the entire system is shown in inset.

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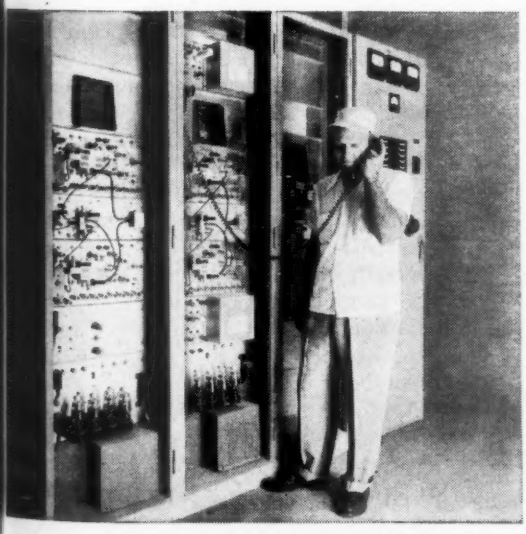

Equipment at Smith booster station includes operating microwave radio repeater assembly, stand-by microwave radio multiplexing equipment and control equipment. Service channel phone gives contact with maintenance crew, speeds servicing.

Smith station supervisory control and telemetering equipment is shown. Panels in center are IT-1 Freq-O-Tron* telemetering transmitters which transmit local pressure and flow over microwave channels.

*Trade Mark

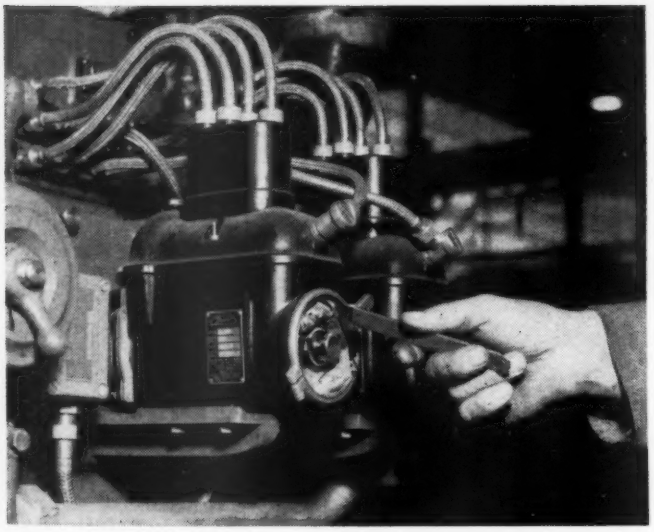

FIG. 3. Checking magneto points clearance.

be installed on the water intake to each compressor cylinder. On some installations, it is desirable to install thermometer wells on the discharge from each cylinder; on others, one on the composite discharge from all the cylinders is adequate.

Frequently, a single pump circulates water through both the engine and the compressor cylinders in parallel. Therefore, if too much water flows through the compressor cylinders, the engine is robbed accordingly. In installations where this is the case, it is particularly important to throttle the compressor cylinder water volume.

One method that is frequently used is to measure the cylinder discharge temperature with the throttling valve or valves fully open. Then, in the case of installations with a reasonably high compression ratio, pinch down on the valve or valves until the temperature increases about five degrees. In this way, the flow is no longer excessive and the engine is getting its required quantity of cooling water. The same throttling procedure could be applied to a shell and tube lube oil cooler when the volume of water flowing through it is critical.

Adequate records should be maintained, which will point out any progressive reduction in cooling ability, usually caused by a build-up of foreign material inside the jackets or the cooling coil in the form of dissolved solids or an oil film. If the trouble is not found and corrected in a reasonable length of time, it can result in scored cylinders and pistons or cracked power cylinder heads. A close periodic check on the condition of the cooling water and any readily exposed metal surfaces will ordinarily give an indication of this dangerous situation.

One of the most damaging conditions that can exist within a jacket water system is for some of the water to become regularly aerated. The most common way is for a line that carries some water back to the surge tank to enter above the water level and thereby fall freely for some distance. Oxygen is thereby drawn into the system continually. This causes a corrosive situation which results in iron oxide deposits being formed in the engine and compressor jackets.

Fuel Gas Systems

The seventh section of this article deals with the fuel gas system. Good clean dry gas of a constant heating value is important for trouble free engine operation. For gasoline plant compressors, the practice of using a mixture of absorbers discharge gas and a high BTU waste gas should be avoided. If a waste gas of this type must be used in some way, it should ordinarily be burned under the boilers and the dry gas left for the compressors.

If wet gas is used for fuel at remote locations, one cannot be too careful to scrub it efficiently. In some instances, it is desirable to install a filter downstream of the scrubber in order to do a particularly good job on the fuel. The higher compression engines of today run better and with greater fuel economy than did their predecessors. They place more importance on dry fuel, however. Liquid carry-over in the fuel system is ordinarily the cause of intermittent detonation—a heavy combustion knock every minute or two. This trouble should be corrected as quickly as possible.

The exact cause for detonation is sometimes a hard one to find. In general, all detonation is caused by a faulty air to fuel mixture. But several factors can cause this situation.

The first, and most usual, cause is a load change. On almost all engines, the intake air supply is either reasonably constant for a given speed or at least it does not vary as much as it should to compensate for a load change. On the other hand, ordinarily the fuel quantity changes to a greater degree. Hence the mixture will usually become richer as the load increases.

As the engine was designed for a certain mixture at a rated load, an overload will therefore cause the mixture to become richer and hence detonation will occur. On a two cycle engine, the same statements can be made with regard to an individual cylinder being overloaded if one or more of the adjusting valves is not adjusted properly.

Another cause of an improper air to fuel mixture is a high ambient air temperature. Frequently an engine runs satisfactorily in the morning and in the afternoon it detonates. If it is balanced in the morning, however, it is likewise balanced in the afternoon. The trouble probably is that, in the afternoon, the air to fuel mixture is too rich, which is caused by too little air. The reduced air density resulting from the high ambient air temperature is probably the cause.

On a two cycle engine, the first reaction is to adjust the adjusting valve on the cylinder which is pounding. This procedure is obviously wrong and will only result in another cylinder beginning to pound, because additional load is shifted to it. Intake air cooling is oridnarily the answer in this situation.

Another cause of detonation is an improperly operating ignition. A faulty electrical system at one cylinder will cause part of that cylinder's load to be shifted elsewhere and hence another cylinder will be overloaded and detonation will occur. The proper clearance should always be maintained between magneto points to assure smooth and economical operation. Before they are checked with a feeler gauge as shown in Fig. 3, it should definitely be determined that there is not pitting.

Carbon deposits on the intake ports will cause a reduction in the amount of air supplied to that cylinder and hence detonation resulting from too rich a fuel mixture. These deposits can be caused from excessive or faulty lubrication within the cylinders. Inadequate cooling water circulation will also cause "hot spots" which in turn cause detonation. The subject of scale deposits in the water system has already been discussed.

It was stated previously that the problems concerning balancing the two cycle engine as a result of a detonation or field inspections is a controversial one. The compressor manufacturers feel that an engine should ordinarily stay balanced when it is adjusted after an overhaul. If the engine starts to detonate, then something else is wrong and one can usually do more harm

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FIG. 4. Engine indicator.

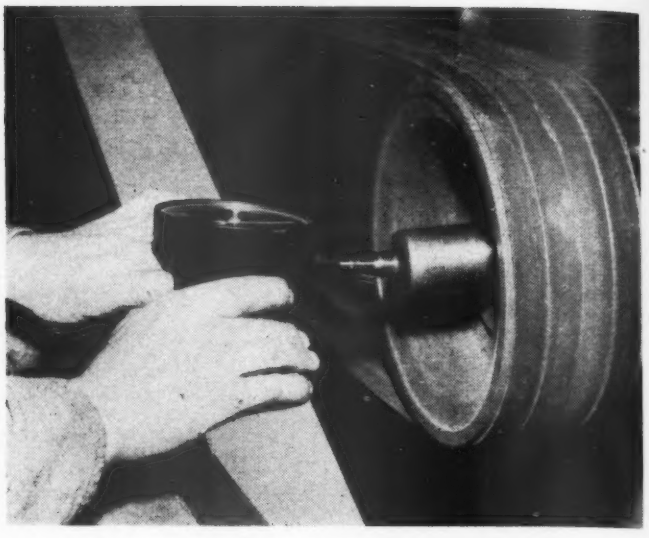

FIG. 5. Checking sheave speed with tachometer.

than good by trying to rebalance the engine at that time.

On a two cycle engine, the exhaust pyrometer is a valuable instrument to locate faulty plugs, coils, condensers, points, and exhaust valves. They give some indication of load but should not be used as the only basis for balancing the engine. As an example, assume that the exhause temperature from a cylinder is high because the air to it is reduced as a result of clogging in the intake ports. If the operator reduces the amount of gas flow to that cylinder because he thinks that the cylinder is overloaded and is thereby causing a high exhaust temperature, he merely shifts some of the load to the other cylinders. They then become overloaded and their life substantially reduced.

The two cycle compressor manufacturers are in agreement that one should rely on "Pull" cards, which indicate compression and explosion pressure, to balance out cylinder loads rather than pyrometer readings. Pyrometer readings may be the tip-off but fuel injection valve clearances should not be changed until "Pull" cards are taken. Fig. 4 shows a Kiene engine indicator which can be used for this purpose.

By-Pass and Safety Valves

The eighth service to be discussed is the starting bypass, unloading, and safety valves. Although there are no troubleshooting problems herein connected, their installation deserves a few general comments.

Ordinarily, a starting by-pass valve is installed when no gas is allowed to be wasted. The utilities use them for this reason. When the compressor cylinders are larger than 12-in., however, a by-pass is usually necessary because the first stroke will pull so much vacuum that the engine will not start. The engine manufacturers have methods to calculate the size of these valves. Their recommendations should be followed in order that a valve is installed which is large enough to do some good.

Relief valves should ordinarily be installed on the discharge of each stage of compression upstream of any block valves. Their capacities should be adequate to handle the total compressed volume at the desired set pressures. An unloading valve on the compressor discharge of the same pipe size as the inlet of the discharge relief valve is ordinarily adequate.

This concludes the discussion on the compressors themselves. To find the causes for trouble on a compressor, however, it is sometimes necessary to study the rest of the compressor installation.

For instance, if the cooling water is too hot, the trouble could well be in the jacket water pump, the cooling coil, the cooling tower or dry cooler, or the temeprature by-pass valve. A tap should be provided to measure the pump discharge pressure. The flow rate can thereby be determined from the pump curve. Some installations have a set of orifice flanges in the line to which a meter can be attached for a check measurement.

If the metered flow rate is substantially lower, the trouble is probably in the pump.

On field compressors, which use belts to drive the radiator and water pump, an excessive cooling water temperature could be the result of belt slippage which would cause the equipment to operate at too slow a speed. Fig. 5 illustrates the use of a tachometer to check the speed of these drives.

Thermometer wells should be located on the water line to and from the engine and, if there is a temperature by-pass valve in the system, one should also be installed on the outlet from the cooling coil before it is blended with the by-passed water. A comparison of these temperatures will indicate the position of the control valve and will ordinarily show whether it is functioning properly.

The trouble could also be in the cooling coil or related facilities. Naturally if the outside of the tubes become scaled, the cooling efficiency will be reduced. But sometimes a film of oil or scale forms inside the tubes. A visual inspection will usually determine whether this is the case. If the trouble is in the cooling tower or dry cooler itself, all of the various cooling services would be equally affected.

Test Data

Sometimes it is necessary to take test data on compressor installations which will be used by the compressor or cooler manufacturer to check the original design calculations. When this is done, it is wise to write down every figure one can think of, including temperatures and pressures, metered and estimated volumes, the quantity and gravity of any liquid withdrawn from the scrubbers, speeds of engines and pumps, wet and dry bulb air temperatures, estimated wind velocity, position of compressor cylinder clearance pockets, and all other pertinent information. Extraneous data can always be destroyed, but it is often impossible to obtain information later that was not recorded at the time.

Good foresight and organization are requisite to carry out the many operations which will simplify future investigations. Adequate preliminary planning will certainly yield big dividends by providing a basis for compressor plant trouble-shooting — the easy way.

Acknowledgment

This discussion was originally presented before a meeting of the coastal chapter, California Natural Gasoline Association, Ventura, California. * *

Wooden Cooling Towers:

Decay Is Major Deterioration Cause†

Research projects indicate that much deterioration attributed to chemical attack is actually due to decay organisms; decay can be prevented by preservatives applied before or after tower erected

DONALD R. BAKER*

WOOD deterioration is not a new problem, and neither is it confined to cooling-tower lumber. It is a well established part of wood technology, the basic causes being known, and our specific problem is to determine how these known laws of Nature affect wood when it is subjected to the conditions found in a cooling tower. Wood technology recognizes two basic types of deterioration — chemical attack and decay. Chemical deterioration, as the name implies, refers to any alteration of the components of the wood due solely to chemical reactions. Decay, or rot, is the deterioration caused by weed-destroying fungi that utilize the wood as food. They secrete enzymes that produce chemical changes in the wood, but the deterioration is distinguished by the fact that it is associated with a living organism. The two kinds of attack are, therefore, similar and not easly distinguished by either the layman or wood technologist.

It is probably safe to assume that chemical attack, including leaching, always precedes decay because conditions causing chemical attack also remove the toxic materials that impart the property of durability to some varieties of wood. Deterioration in the non-flooded parts of a tower often has the appearance of typical decay with no indication of chemical attack. Deterioration in the flooded parts usually has the appearance of chemical attack even if decay is also present, although decay organisms are sometimes present when neither type of attack is obvious.

It is necessary to consider decay to some extent because infection of wood-destroying organisms is probably always preceded by chemical attack. Wood is not a specific compound and one of the problems encountered in research work of this nature is the selection of a means of evaluating the changes that occur in the wood when deterioration takes place.

TABLE 1. Results obtained by Moberg when leaching redwood in various solutions for 60 days.

Sample	Solution	pH	Extraction grams	Loss in weight
1	1000 ppm Na_2CO_3	10.94	1.9498	1.16%
2	3000 ppm Na_2CO_3	10.94	2.0815	1.24%
3	6000 ppm Na_2CO_3	10.95	2.1872	1.46%
4	9000 ppm Na_2CO_3	10.95	2.2645	1.56%
5	12000 ppm Na_2CO_3	10.95	2.3345	1.64%
6	15000 ppm Na_2CO_3	10.95	2.6792	1.89%
7	18000 ppm Na_2CO_3	10.95	3.3485	2.02%
8	36000 ppm Na_2CO_3	10.95	4.2005	2.84%
9	36000 ppm NaCl	7.49	0.7770	0.21%
10	36000 ppm Na_2SO_4	7.51	0.5128	0.18%
11	36000 ppm $CaSO_4$, $MgSO_4$, NaCl	7.2	0.4165	0.15%
12	36000 ppm $CaSO_4$, $MgSO_4$, NaCl	7.4	0.3210	0.11%
13	24000 ppm $CaSO_4$ plus $MgSO_4 H_2SO_4$, NaCl	5.01	2.1732	1.22%
14	H_2O plus H_2SO_4	4.50	2.2775	1.48%
15	24000 ppm mixed salts plus H_2SO_4	7.20	0.0290	0.08%

Chemical Deterioration

Wood is composed of approximately 70 per cent carbohydrates consisting of cellulose or closely associated materials and 30 per cent lignin, plus extraneous matter existing within the cells but adding nothing to the structural strength. Wood withstands a wide variety of conditions without serious deterioration. The cellulosic components are degraded or hydrolyzed by acids, while alkalies or oxidizing agents attack the lignin and also the toxic extractives found in redwood. The conditions found in a cooling tower are extremely mild as compared to exposures found when wood is used in the construction of tanks, or in the deliberate destruction of wood that occurs in paper making.

Laboratory Experiments. The earliest published information on chemical deterioration of cooling-tower lumber seems to be that of Moberg.[1] His tabulations are shown in Table 1 covering results obtained when leaching redwood for 60 days in various strengths of chemicals commonly found in cooling towers. Moberg dried his samples in an oven at 95 C for 49 hr before and after leaching, and based his evaluations on the loss of weight. Sodium carbonate was the only material used that had an appreciable effect, and the loss in weight was almost directly proportional to the concentration which was varied from 1000 to 36,000 ppm. The loss in weight under these conditions includes the removal of lignin or carbohydrates from the cell walls, and also the removal of extraneous matter that will lower the durability to decay but have no effect on the structural strength of the wood.

The former only partially accounts for changes in structural properties because the removal of lignin might not lower the strength of the cellulose fibers but greatly reduces the strength of the wood. Neither does it take into account the fact that some components may be degraded and altered to other compounds without actually being removed. Nevertheless, the over-all results of his work have been confirmed in general by more recent tests using other methods of evaluation. His investigation included the inspection of a large number of cooling towers and concluded that prevention "depends" almost entirely on the elimination of sodium bicarbonate or sodium carbonate from the circulating water."

Forest Products Laboratory Investigation. A project was undertaken by the Forest Products Laboratory in 1950, to determine more accurately the chemical changes that occur when redwood is leached in distilled water and solutions of sodium carbonate and chlorine. The leaching was done[2] by placing 10 water-logged sections in a flask of each of 7 solvents and immersing the flasks in boiling water for 1, 3, 9, and 27 days. The 280 sections, consisting of 28 groups of 10 each, were cut from a single piece of redwood to assure uniformity. Adjacent pieces were analyzed to determine the amount of hot-water extractives in the original wood. The amount of residual

†Presented at ASME Oil and Gas Power Division meeting, Kansas City, 1954; original title, "A Summary Report of Projects Dealing with the Deterioration of Cooling-Tower Lumber.

*Technical Service Department, The Marley Company, Kansas City, Missouri.

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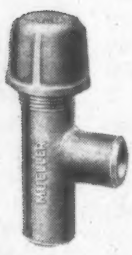
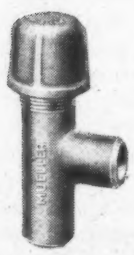


Service Tee

The Mueller No-Blo Service Tee with welding or threaded inlet and welding, threaded or extended outlet—used for making connections under pressure where a valve is not required but a means of future stop-off is desired. Sizes ¾" through 2".



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Curb Valve Tee

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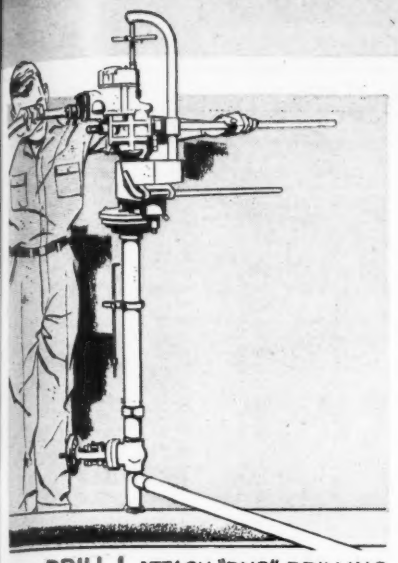
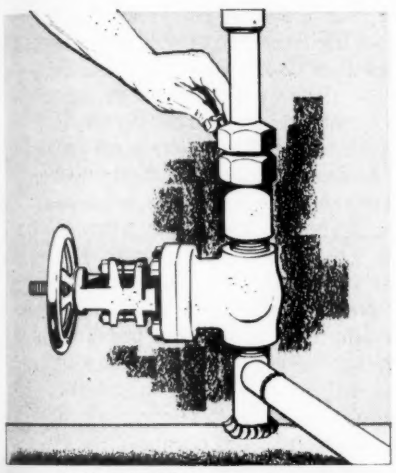


STEP 2. **DRILL!** ATTACH "DH2" DRILLING MACHINE TO GATE VALVE. DRILL HOLE IN LINE. RETRACT BORING BAR AND CLOSE VALVE. OPEN BLEEDER VALVE TO RELIEVE PRESSURE. REMOVE DRILLING MACHINE.

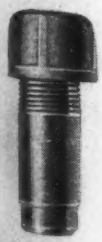
R "H2" DRILLING MACHINE



STEP 4. **COMPLETE!** OPEN BLEEDER VALVE ON BOTTOM OF COMPLETION MACHINE TO CHECK FOR TIGHT SHUT-OFF. THEN REMOVE EQUIPMENT AND INSTALL COMPLETION CAP.

The "DH2" Drilling Machine drills from ¼" through 2¼". Boring bar travel is 14". Maximum working pressure is 1200 psi at 100° Fahrenheit. Maximum working temperature is 500° Fahrenheit at 1000 psi. The "DH2" may be hand-operated or power-operated with the H-600 Air Motor or H-602 Gasoline Engine Drive Unit. Tools may be fed manually or automatically.

For additional information on the "DH2" and related No-Blo Fittings, consult your Mueller Representative, "DH2" Catalog, or write direct.



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This is another of a series showing the broad application of Mueller No-Blo Fittings and Machines used for their installation.

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TABLE 2. Results of decay tests and chemical analyses after leaching 1, 3, 9, and 27 days.

Group	Sample No.	Leaching conditions	Original hot-water extractive Percent	Residual extractives: Hot water Percent	Residual extractives: Alcohol-benzene Percent	Cellulose (Cross & Bevan) Percent	Lignin Percent	Ratio of cellulose to lignin	Weight loss due to: 4856[1] Percent	Weight loss due to: 4789[1] Percent	Weight loss due to: Poria monticola Percent	Weight loss due to: Lenzites trabea Percent
	1	1 day in water	11.4	3.40					0	3.0	39.3	21.5
1	2	3 day in water	11.4	1.59					0	6.8	46.8	25.7
	3	9 day in water	11.2	1.38					0	8.0	47.4	22.2
	4	27 day in water	11.2	1.37	.56	53.8	36.4	1.48:1	0	7.9	50.8	....
	5	1 day in 2000 ppm Na_2CO_3	11.3	3.26					24.5	53.4	51.9	32.2
	6	3 day in 2000 ppm Na_2CO_3	11.4	3.21					25.4	54.8	51.0	47.2
2	7	9 day in 2000 ppm Na_2CO_3	11.0	2.73					24.1	52.9	53.7	47.6
	8	27 day in 2000 ppm Na_2CO_3	10.9	2.66	.41	57.8	34.8	1.66:1	24.8	41.8	54.6	....
	9	1 day in 200 ppm Na_2CO_3	11.4	2.66					4.0	29.1	38.2	22.4
	10	3 day in 200 ppm Na_2CO_3	11.4	1.57					9.4	38.6	45.0	33.4
3	11	9 day in 200 ppm Na_2CO_3	9.7	1.47					11.8	32.9	53.0	42.0
	12	27 day in 200 ppm Na_2CO_3	9.7	1.47	.26	56.0	35.1	1.59:1	13.6	33.2	52.3	....
	13	1 day in 2000 ppm Na_2CO_3 + Air	11.0	3.46					20.9	43.3	51.2	31.9
	14	3 day in 2000 ppm Na_2CO_3 + Air	11.2	3.53					22.2	39.9	53.7	42.4
4	15	9 day in 2000 ppm Na_2CO_3 + Air	10.0	3.19					20.6	46.2	54.5	34.6
	16	27 day in 2000 ppm Na_2CO_3 + Air	10.0	3.17	.24	51.4	33.7	1.52:1	20.2	68.6	55.4	....
	17	1 day in 200 ppm Na_2CO_3 + Air	11.0	3.38					3.0	16.4	37.7	20.2
	18	3 day in 200 ppm Na_2CO_3 + Air	11.3	2.13					8.8	32.4	41.0	32.0
5	19	9 day in 200 ppm Na_2CO_3 + Air	10.0	1.69					12.8	40.8	49.6	36.2
	20	27 day in 200 ppm Na_2CO_3 + Air	10.0	1.69	.11	57.2	35.0	1.63:1	16.5	47.6	54.4	....
	21	1 day in 100 ppm Cl_2	10.8	2.82					0	9.6	39.0	25.6
	22	3 day in 100 ppm Cl_2	9.9	2.20					0.9	15.9	41.0	27.0
6	23	9 day in 100 ppm Cl_2	10.0	1.74					2.9	20.2	49.2	21.6
	24	27 day in 100 ppm Cl_2	9.8	1.45	.32	56.2	35.9	1.57:1	2.2	26.0	52.8	....
	25	1 day in 10 ppm Cl_2	10.3	3.12					0	2.0	38.0	17.4
	26	3 day in 10 ppm Cl_2	9.7	1.54					0	8.2	45.2	23.2
7	27	9 day in 10 ppm Cl_2	10.0	1.26					0	9.6	50.9	27.3
	28	27 day in 10 ppm Cl_2	10.0	1.05	.37	55.5	36.9	1.54:1	0	6.2	53.0	....
	29	Unleached							0	1.6	22.8	9.4

[1] Cultures Nos. 4856 and 4789 were isolated from decayed redwood cooling-tower slats.

TABLE 3. Comparison of results from Table 2 after leaching 1 day.

Group	Solution	Loss of weight due to[1]: 4856	4789	Poria monticola	Lenzities trabea	Percent Hot-water extractives	Ratio[2] cellulose to lignin
Unleached	Water	0	1.6	22.8	9.4	10.5	1.42/1
7	10 ppm Cl_2	0	8.2	45.2	23.2	3.12	1.54/1
1	H_2O	0	6.8	46.8	25.7	3.40	1.48/1
6	100 ppm Cl_2	0.9	15.9	41.0	27.0	2.82	1.57/1
5	200 ppm Na_2CO_3, Arerated	8.8	32.4	41.0	32.0	3.38	1.63/1
3	200 ppm Na_2CO_3	9.4	38.6	45.0	33.4	2.26	1.59/1
4	2000 ppm Na_2CO_3, Arerated	22.2	39.9	53.7	42.4	3.46	1.52/1
2	2000 ppm Na_2CO_3	25.4	54.8	51.0	47.2	3.26	1.66/1

[1] Cultures 4856 and 4789 were isolated by the U. S. Forest Products Laboratory from decayed redwood in cooling towers.
[2] Per cent hot-water extractives and ratio of cellulose to lignin based on analyses after 27 days of leaching.

extractive soluble in hot water and alcohol-benzol was determined for each leaching period, and those leached 27 days were analyzed for cellulose and lignin. A visual examination of the specimens showed a greater variation in chemical deterioration than was disclosed in these determinations.

Decay tests also were run in which the test blocks were inoculated with the culture of a wood destroyer and allowed to incubate under controlled conditions for 90 days. The loss of weight serves as a measure of the damage done by the fungus. Two of the organisms, Poria monticola and Lenzites trabea, normally produce brown rot in softwood, and the other two are cultures of white rots isolated from infected cooling-tower lumber. The decay tests serve as a direct measure of the loss of durability, and they also proved to be a quite accurate indication of the amount of chemical attack that had taken place. The results are shown in Table 2.[2]

The ratio of cellulose to lignin increased in all cases over that normal for redwood, indicating a loss of lignin that can be caused by either alkalies or oxidizing agents. The toxic extractives of redwood generally are considered to be soluble in hot water, and they showed considerable loss during the leaching, but the reduction in durability did not follow too closely the loss of hot water extractives. The trends became apparent in the 1 and 3-day exposures and seem to reach a maximum and became constant before the 9 days or 27 days were reached. A comparison of the results at the end of 1 day are shown in Table 3. Leaching in distilled water resulted in some loss in durability. A chlorine concentration of 10 ppm, which is in excess of that normally used to control algae, caused slightly less damage than distilled water in most cases. A chlorine concentration of 100 ppm had about the same effect as 200 ppm of sodium carbonate which is not an unusual concentration.

A second project[3] was undertaken at a later date to determine if other impurities commonly found in circulating waters contribute to chemical attack. Both chemical attack and decay lower the structural strength of wood, and the Forest Products Laboratory used a Tinus Olsen stiffness tester in this series of experiments to evaluate the effect of the various solutions on the wood. The objective was to obtain accelerated tests that would reasonably approach actual operating conditions. Eight chemicals were selected that are commonly present in circulating waters. The concentrations were within the range of possibilities but above that commonly encountered in service. The leaching was done at 50 C (122 F) which is a high average temperature of the water to a cooling tower.

All specimens were cut from a single block of straight-grained redwood having normal density. They were arranged in sets of five in order to obtain five replicates, with adjacent sets used as controls. Table 4 shows the average breaking strengths in inch-pounds. The per cent strength as compared to the control pieces is shown in Table 5. It is interesting to note that the breaking strengths of the control pieces did not decrease to any great extent as the leaching time increased. The variations of the controls for each duration of exposure show how the properties of wood may vary within a single board.

The relative effect of the various materials changed somewhat with time, but the sulphates and sodium chloride resulted in the least reduction in strength, and in most cases had less effect than distilled water. Sodium hypochlorite in a concentration of 100 ppm had a surprisingly small effect, while its relative effect at 1000 ppm became progressively worse as the time of exposure increased. The two acid salts, ferrous sulphate and sodium bisulphite, had less effect than might be expected

Sodium Carbonate Effect

Former laboratory tests, as well as operating experience, indicate the harmful effect of sodium carbonate which was again verified. Sodium bicarbonate was included in this series of tests because operating experience indicates that it is harmful to the lumber in a cooling tower. A concentration of

TABLE 4. Breaking strengths of thin sections after leaching 1, 3, and 9 months.

Group	Solution	ppm Strength	Average breaking strength (in.-lb)* 1 Month Test piece	1 Month Control piece	3 Months Test piece	3 Months Control piece	9 Months Test piece	9 Months Control piece
1	Na_2CO_3	1,000	1.33		1.18		.79	
2	Water			2.06		1.77		1.83
3	Na_2CO_3	10,000	.97		.78		.59	
4	$NaHCO_3$	1,000	1.96		1.75		1.54	
5	Water			2.12		2.00		1.92
6	$NaHCO_3$	10,000	1.71		1.52		1.06	
7	NaOCl	100	2.05		2.19		1.70	
8	Water			2.01		2.09		1.91
9	NaOCl	1,000	1.65		1.02		.12	
A	Na_2SO_4	1,000	1.81		1.99		1.78	
B	Water			1.60		1.87		1.80
C	Na_2SO_4	10,000	1.70		1.84		1.68	
D	$NaHSO_3$	1,000	1.82		1.69		1.37	
E	Water			1.80		1.94		1.86
F	NaCl	1,000	1.91		1.62		2.05	
H	$CaSO_4$	1,000	2.23		2.36		2.09	
J	Water			2.28		2.16		2.04
K	$FeSO_4$	1,000	2.08		1.87		1.50	

* Each value is the average of 5 replicates.

10,000 ppm was much more harmful than 1000 ppm, although the latter concentration did not appear to be too detrimental in the leaching tests. Many observations of actual cooling-tower installations show that serious deterioration of the wood in the flooded portions of the tower occurs when concentrations of sodium bicarbonate are as low as 200 ppm.

Table 6 shows the pH values of the solutions at various stages during the leaching tests. The solutions were changed daily for the first 5 days and weekly thereafter. Variations in pH-values for the different solutions probably reflect the effect of materials dissolved from the wood. The relationship between initial pH-value and the percentage breaking strengths at the end of 3 and 9 months is shown in Figs. 1 and 2, respectively.

TABLE 5. Data from Table 4 showing per cent break strengths.

Rank	1 Month ppm	1 Month Solution	1 Month Percent	3 Months ppm	3 Months Solution	3 Months Percent	9 Months ppm	9 Months Solution	9 Months Percent	pH Initial	pH 1 Month
1	1,000	Na_2SO_4	1.13	1,000	$CaSO_4$	1.09	1,000	NaCl	1.10	5.53	4.97
2	10 000	Na_2SO_4	1.06	1,000	Na_2SO_4	1.06	1,000	$CaSO_4$	1.02	5.53	4.75
3	1,000	NaCl	1.06	100	NaOCl	1.05	1,000	Na_2SO_4	.99	5.65	5.27
4	100	NaOCl	1.02	10,000	Na_2SO_4	.98	10,000	Na_2SO_4	.93	5.56	6.72
5	1,000	$NaHSO_3$	1.01	1,000	$NaHCO_3$	.88	100	NaOCl	.89	7.55	5.80
6	1,000	$CaSO_4$	.981	1,000	$NaHSO_3$	.87	1,000	$NaHCO_3$	.80	7.71	7.81
7	1,000	$NaHCO_3$	.920	1,000	$FeSO_4$	.87	1,000	$FeSO_4$	.74	3.43	3.33
8	1,000	$FeSO_4$	.920	1,000	NaCl	.83	1,000	$NaHSO_3$	.74	3.25	4.36
9	1,000	NaOCl	.820	1,000	$NaHCO_3$	.76	10,000	$NaHCO_3$	.55	8.03	8.33
10	10,000	$NaHCO_3$	.81	1,000	Na_2CO_3	.67	1,000	Na_2CO_3	.43	10.43	10.43
11	1,000	Na_2CO_3	.65	1,000	NaOCl	.49	10,000	Na_2CO_3	.32	10.92	10.92
12	10,000	Na_2CO_3	.47	10,000	Na_2CO_3	.44	1,000	NaOCl	.06	10.10	6.13

TABLE 6. pH-Values of solutions used in leaching tests reported in Tables 4 and 5.

Solution	ppm Concentration	% breaking strength after 9 mos.	pH Value Initial	After 24 hrs.	After 1 mo.	After 3 mos.	After 9 mos.
NaCl	1,000	1.104	5.53	4.08	4.97	4.24	6.07
$CaSO_4$	1,000	1.027	5.53	3.67	4.75	3.10	5.86
Water		1.000	5.78	4.32	4.96	5.73	6.25
Na_2SO_4	1,000	.980	5.65	4.05	5.27	5.33	6.63
Na_2SO_4	10,000	.915	5.56	3.87	6.72	7.37	6.94
NaOCl	100	.893	7.55	4.52	5.80	6.62	7.76
$NaHCO_3$	1,000	.805	7.71	6.97	7.81	8.72	8.82
$FeSO_4$	1,000	.739	3.43	3.47	3.33	3.25	3.12
$NaHSO_3$	1,000	.739	3.25	3.67	4.36	3.26	2.46
$NaHCO_3$	10,000	.555	8.03	7.97	8.33	8.86	8.81
Na_2CO_3	1,000	.431	10.43	8.93	10.36	10.33	10.22
Na_2CO_3	10,000	.323	10.92	10.18	10.92	10.83	10.80
NaOCl	1,000	.061	10.10	4.94	6.13	7.17	7.32

Fig. 3 shows the relationship between percentage breaking strength and time for each solution. It will be noted that the neutral salts had about the same effect as distilled water. The two acidic salts caused some reduction in strength, sodium bisulphite doing considerable more damage than the same concentration of sodium sulphate. Varying the concentration of sodium sulphate from 1000 to 10,000 ppm had a negligible effect on strength and pH-value. Increasing the concentration of the sodium hypochlorite, bicarbonate, and carbon solutions resulted in greater reduction in strength and also increased the pH-values. These results show that the effect on the wood is not primarily a function of pH-value, but ° F the chemicals present and their concentration.

Deterioration at Iron Fastenings

Chemical deterioration often occurs

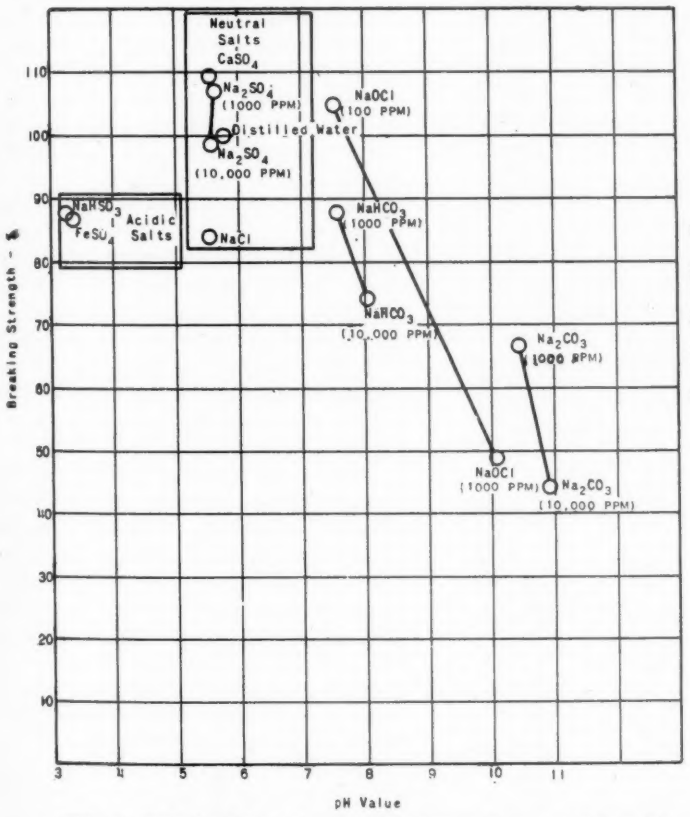

FIG. 1. Relationship between pH-value and per cent breaking strength after leaching thin redwood specimens in various solutions for 3 months; percentage based on controls leached in distilled water.

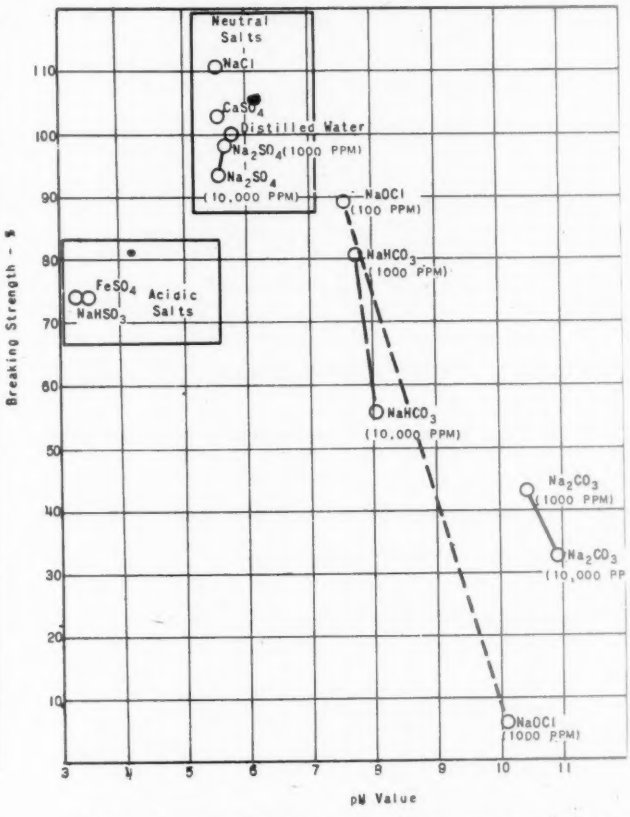

FIG. 2. Same as Fig. 1, but showing results after leaching 9 months.

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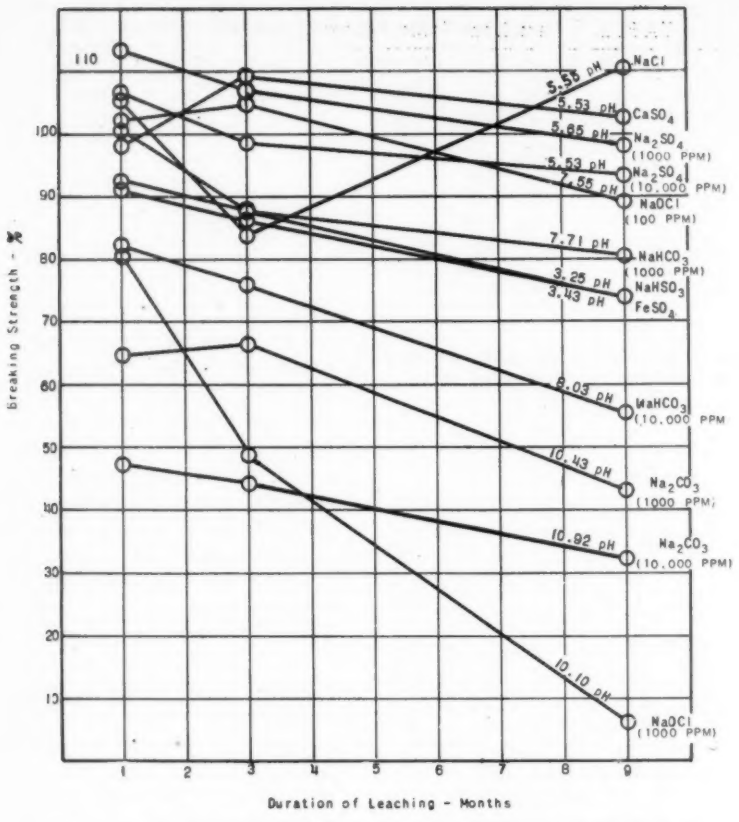

FIG. 3. Relationship between per cent breaking strength and duration of leaching for series of tests referred to in Figs. 1 and 2.

in wood at points adjacent to iron fastenings, and this condition has been found in cooling towers but only in the non-flooded portions. This type of deterioration is attributed to the products of corrosion which may act as oxygen carriers, and it was for this reason that ferrous sulphate was included in the chemicals used in the leaching tests. The results show that a concentration of 1000 ppm can cause some chemical attack, and higher concentrations are conceivable in localized areas.

The Forest Products Laboratory at first suspected the deterioration of cooling-tower lumber to be due largely to chemical attack. Specimens of wood collected during a field inspection in 1949 were analyzed in Madison, and the results are shown in Table 7.[4] The first six samples in the table show a comparison of the analysis of the sound and deteriorated portions of three pieces of wood. In all instances the iron content was higher in the deteriorated portion. It has not been possible to determine if this resulted from the fact that the deteriorated portions were in closer proximity to the iron fastenings, or if the iron had anything to do with the deterioration. The reduction in amounts of extractives might be the result of oxidation due to the action of the iron. This may have lowered the resistance to decay and allowed the wood-destroying organisms to attack the wood. As decay is not limited to wood adjacent to iron, and iron is not always present in the deteriorated wood, its role cannot be established definitely.

Any oxidation resulting from the presence of ferrous compounds should increase the ratio of cellulose to lignin. Table 3 shows that the ratio increased during the leaching tests, but Table 7 shows that the ratio is lower in deteriorated specimens of cooling-tower lumber.

Similiar results were obtained by the Institute of Paper Chemistry in a project sponsored by the California Redwood Association where the only exception was an analysis of the outer portion of wood having a white surface attack typical of what is called "delignified" wood.

TABLE 7. Results of chemical analyses of exposed and unexposed redwood.

No.	Description of sample	Cross & Bevan cellulose Percent	Lignin Percent	Ratio C & B cellulose to lignin	Alcohol-benzol extract Percent	Hot-water extractives Percent	Sulphur Percent	Iron Percent
1	Sound portion of 2 x 6 containing black streaks.	52.2	35.4	1.47/1	1.4	3.4	...	0.34
2	Deteriorated end of No. 1, in contact with iron clip.	41.5	34.8	1.19/1	0.49	4.9	...	7.7
3	Sound part of another 2 x 6 same tower. No black streaks.	47.5	34.2	1.39/1	9.1	3.9	...	0
4	Deteriorated end of No. 3.	38.9	37.3	1.04/1	5.6	6.2	...	4.9
5	Sound portion of eliminator slat containing decay.	51.2	36.5	1.40/1	1.5	3.8	...	
6	Narrow band of No. 5 in contact with iron support. Decay similar to No. 2.	47.3	36.2	1.31/1	.74	4.2	...	.62
7	Deteriorated interior of 1 x 6 casing, containing decay. White rot similar to No. 10.	48.5	36.7	1.32/1	.59	3.8	.21	0
8	Another instance of decay of inside casing. Typical brown rot.							.73
9	Section of sound 2 x 4 eliminator support. Decay in other part of tower.	47.7	36.6	1.30/1	2.2	3.0	.18	0
10	Analysis of interior of eliminator slat. Same tower as No. 9. Stringy white rot.	50.1	40.8	1.23/1	.07	4.0	.12	0
11	Unused redwood.	48.5	34.2	1.42/1	12.1*	9.8	.045	0

* The alcohol-benzol extractive was not determined on this sample. The value given was obtained on a separate sample.

Summary of Chemical Deterioration

Neutral salts commonly present in the circulating water have little effect on cooling-tower lumber when tested under laboratory conditions.

Acid salts may occur in the circulating water owing to the presence of sulphur compounds or ferrous iron. These materials weakened the wood to a small extent in the leaching tests. Their action should be to delignify the wood and remove toxic extractives.

The concentration of chlorine in a cooling tower seldom exceeds a few ppm and should not have any appreciable effect on the wood.

Appreciable damage was done in the leaching tests by sodium carbonate. Sodium bicarbonate had less effect, although experience indicates that concentrations of either one in excess of 100 ppm usually results in appreciable chemical attack. The chemical analyses of wood leached in solutions of these two carbonates and in chlorine show a removal of lignin.

Chemical analysis of deteriorated cooling-tower lumber usually shows that the cellulose is selectively removed faster than the lignin. The conditions causing chemical attack in a cooling tower should have the opposite effect. Conditions are present that can cause chemical deterioration although the concentrations are so mild that the attack is undoubtedly slow and should be confined largely to the surface of the wood. The alkalies and oxidizing agents have the effect of removing lignin and extractives as is indicated in the leaching tests. The fact that these conditions do not appear in deteriorated wood indicates that the actual attack may be

largely the result of microorganisms that infect the wood after the chemical attack reduces the durability.

Chemical attack can be minimized by exercising care in the use of oxidizing agents. The principal cause of chemical attack appears to be the presence of sodium carbonate or bicarbonate in the circulating water. These may be converted to the sulphates by the use of sulphuric acid. Some operators have used sulphur burners in this connection. The sulphur dioxide will produce sulphites rather than sulphates so serious chemical deterioration can occur unless the sulphites are oxidized to sulphates in the tower. There is evidence that this conversion is taking place. The number of towers that have used sulphur burners is relatively small. None has been observed which shows obvious chemical attack, but the incidence of decay in these towers indicates that there may be some correlation. Operators who contemplate the use of sulphur burners should bear this in mind and make frequent inspections until it is determined definitely if a correlation exists.

Decay

Wood Preservatives. It has already been pointed out that chemical attack lowers the resistance to decay. Wood is used in many types of service where decay is prevalent, and wood preservatives will increase the useful life of lumber in such cases. A few cooling towers have been built of pressure-treated lumber in the past, but reliable service records are not available so it is not possible to evaluate the benefits at this time. Several service tests are now in progress, including one accelerated test. The standard service test runs for 20 years, so it will be many years before those in progress are completed. The preliminary results of the accelerated service test show that the treated wood is more durable than untreated wood after 1 year of exposure, but it will not be possible to draw definite conclusions until the wood has been exposed from 3 to 5 years.

Nevertheless, it should be safe to assume that preservatives will prolong the life of wood in cooling towers. The lumber in cooling towers is subjected to severe leaching so satisfactory results will depend on deep penetration, a high retention of chemicals, and relatively insoluble preservatives. These conditions may be met by the use of insoluble preservatives applied as a pressure treatment before the tower is erected. An alternate method offering a number of advantages is the diffusion treatment.

Diffusion Treatment. The diffusion treatment is based on the phenomenon that a dissolved solid will diffuse from

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a solution through the water in wet wood at a more rapid rate than the solution will penetrate dry wood. Diffusion treatments have been used for many years, but the Forest Products Laboratory developed the double-diffusion method in 1942 that uses two solutions applied successively. Much better penetrations are obtained in this way. The chemicals react within the wood to form an insoluble precipitate that is toxic to the wood-destroying organisms.

The materials available for use in this treatment are similar to many of the well-known salt treatments now in use. Tests have shown that the penetration and retention obtained are equal to that obtained by pressure treatment. It can be applied at any time after a tower is built and a chemical analysis of the wood will show the amount of preservative in the wood, so the treatment can be repeated when or if necessary.

The treatment should not be applied until the wood is thoroughly wet, so a new cooling tower should not be treated until it has been in operation about a year. Little deterioration occurs during the first year so there is little danger in such a delay. Older towers should not be treated until after repairs have been made and all weakened wood replaced.

A number of cooling towers have been treated by this process during the last two years.[5] Wood from the towers was analyzed soon after treatment and periodically thereafter. The initial retentions have been good and there is no evidence of appreciable leaching. The first few towers were treated by the owners themselves, but many users were discouraged by the preparation necessary to apply the treatment. The treatment is now being offered commercially and the acceptance of the service indicates that many towers may soon be treated by this method.

Conclusions

Chemical attack is closely related to the composition of the circulating water. The composition is subject to control through water treatment, but cost does not always make this practical. The operator can avoid practices that increase the rate of chemical attack, such as excessive chlorination or the use of sodiumzeolite softeners that produce sodium carbonate. Sulphuric acid can be used to lower the pH-value and decrease the alkalinity, but there are many instances where the cost of treatment will exceed the cost of replacing old lumber in the cooling tower.

Chemical attack renders the wood susceptible to decay, and there is evidence to indicate that the lumber in most cooling towers soon becomes vulnerable to attack. Laboratory tests indicate that the composition of the circulating water in most towers should not cause serious chemical attack. There is considerable evidence to indicate that much of the deterioration commonly attributed to chemical attack is actually caused by decay organisms. If this is true, wood preservatives offer the possibility of preventing most of the deterioration in cooling-tower lumber.

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* * *

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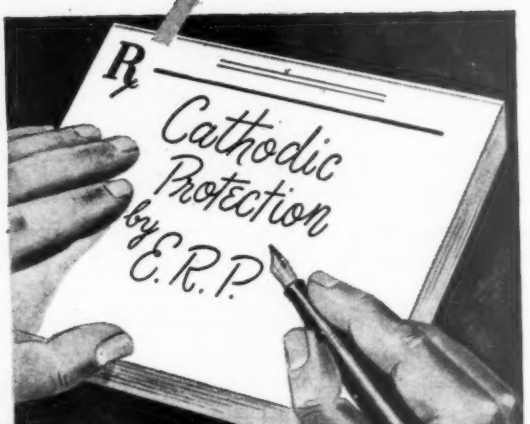

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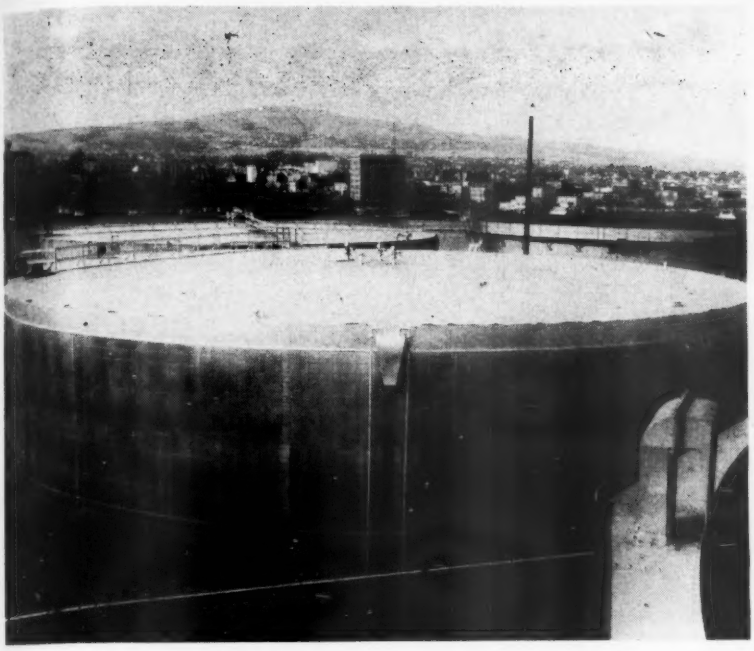

FIG. 1. View of completed tank.

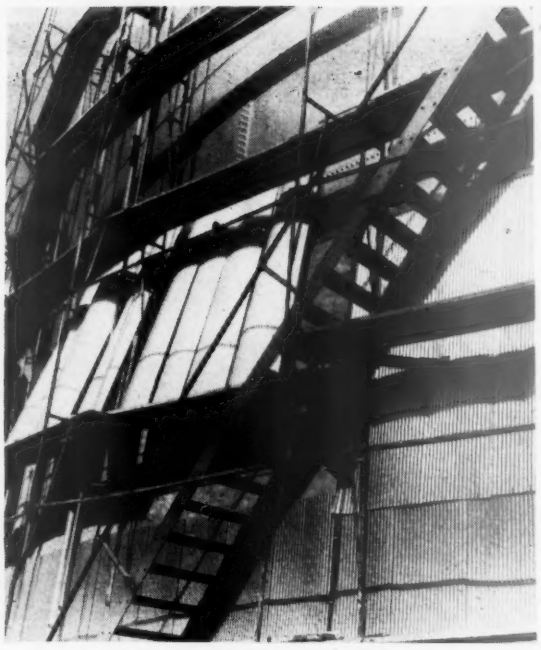

FIG. 2. Embossed corrugated aluminum sheets used to encase Fiberglass blocks.

New Method

Insulating Hot Oil Storage Tanks

Glass fiber blocks encased in aluminum sheets used on California installation to reduce heat loss

M. M. TILLEY

CORRUGATED aluminum sheets[1] and glass fiber insulation[2] provide a new means of insulating hot oil storage tanks on General Petroleum Corporation's tank farm at Terminal Island, California. Glass fiber blocks completely encased by aluminum sheets serve to reduce heat loss, at the same time giving the oil tanks an outstanding appearance. (Fig 1). Simplicity of applying the blocks and aluminum plus overall installation costs has created a widespread interest in this method of insulating tanks.

The importance of this new application merits more than passing interest. The origin and ideas behind the undertaking, as well as installation details, should prove beneficial to all companies having hot storage tanks.

Use of aluminum to cover the glass fiber insulation was decided by General Petroleum Corporation after Frank Lennon, construction superintendent, and R. C. Taylor, Terminal Island tank farm superintendent, inspected an aluminum warehouse building in the Wilmington Harbor area of California (near San Pedro). The building, erected five years ago, is at water's edge and has been constantly exposed both to atmospheric conditions and to the severe corrosive action of salt water. A visual comparison was made between the aluminum siding of the warehouse and similar structures made of galvanized iron at the same location. The aluminum showed little sign of deterioration. Galvanized sheets were badly rusted. Because of this, the decision was made to proceed with aluminum sheets as a protective covering for the glass fiber insulation.

The complete engineering of the installation was supervised by Richard Poole of the Fiberglass Engineering and Supply Company in cooperation with Kaiser Aluminum and General Petroleum Corporation engineers. With the quality of the insulating material and the aluminum sheets known, the problem then centered in the application. Several plans were considered but an entirely new method was used to apply

EXCLUSIVE

[1]Kaiser Aluminum and Chemical Corporation.
[2]Owens-Corning Fiberglas Corporation.

The Author

M. M. Tilley, engineer with Kaiser Aluminum and Chemical Corporation, had construction experience on the San Francisco bay bridge and Boneville Dam projects before obtaining a ME degree at the University of Nevada. Prior to joining Kaiser Aluminum, he was with General Petroleum, Rheem Manufacturing Company, and also acted as a consulting engineer. He has had extensive experience in engineering and design work involving aluminum applications and has a special interest in fields where the thermal and reflected insulation properties of aluminum are important.

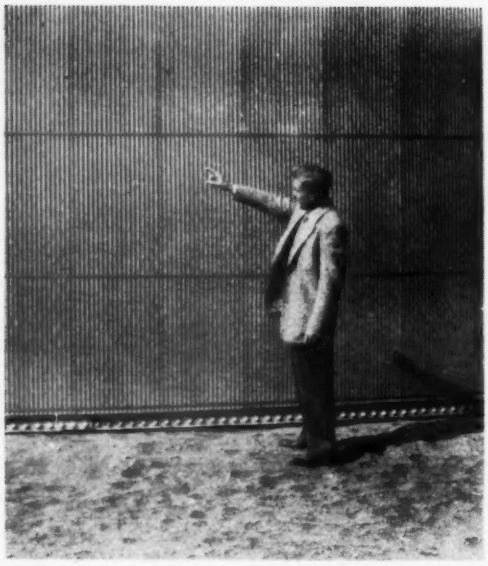

FIG. 3. R. C. Taylor, Terminal Island tank farm superintendent, points out embossed corrugated aluminum sheets on hot oil storage tanks.

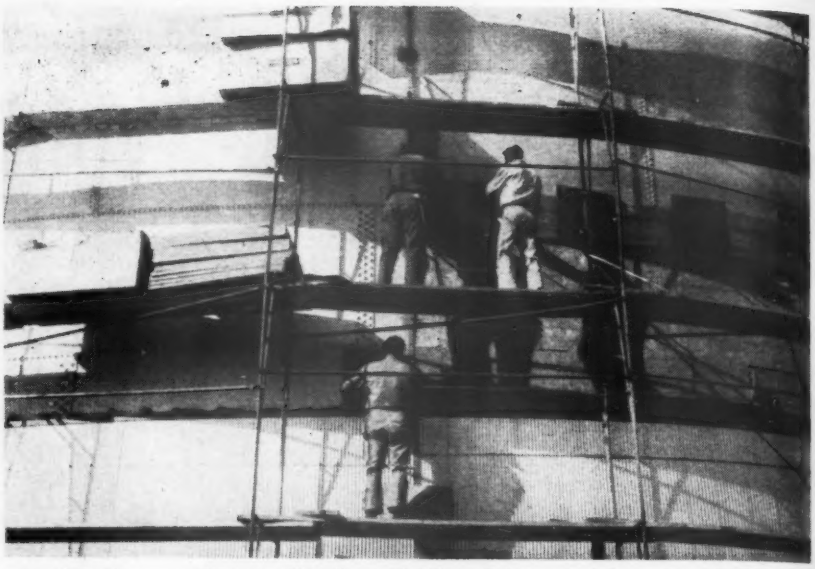

FIG. 4. Simple scaffolding, light materials, and rapid handling speed insulation of hot oil storage tanks.

both the insulation and the sheeting to the tank. As a result of this innovation, one of the most economical and practical methods of insulating hot oil storage tanks has been devised.

Application of Insulation and Siding

Because of the size of the tank — 120 ft in diameter by 40 ft high — it was decided to divide the outer area of the tank into individual units or sections. This was done by marking off the tank into eight segments, with each segment subdivided into an upper and lower elevation or cell. In deciding upon the sectional installation method, commercially available 1½ in. by 2 ft by 4 ft glass fiber blocks and standard size 0.024 in. thick, 26 in. wide, 10 ft long Kaiser aluminum corrugated sheets were used. No special cutting or fitting was required for either material; consequently, little waste or scrap resulted.

The first step was complete scaffolding erection. The second step in applying insulation required placing a light weight angle-iron step of facing around the base of the tank just clear of the

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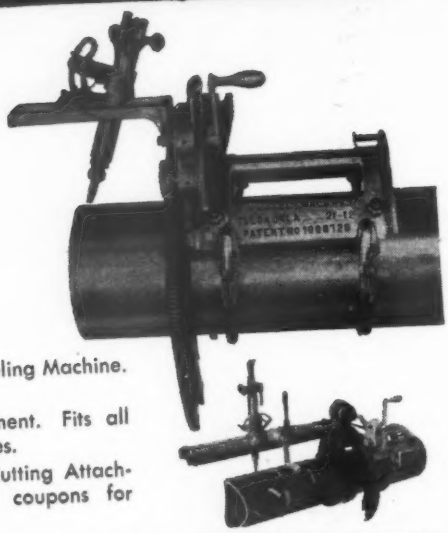

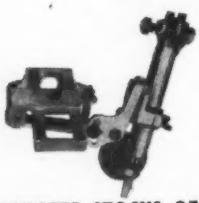

Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

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HOT DOPE

Straight from the Kettle on *PIPE PROTECTION*

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By Boyd Mayes

• Ever think about how specialized everything's gettin' to be? One doctor helps get the baby born, and right there he quits. You gotta get another specialist to keep the kid going. One mechanic works on your automobile brakes and sends you around the corner to get the radiator leak mended. Try gettin' your house fixed and the brick man won't touch the boards. If it keeps up the present trend you may some day have to have a separate painter for each color. Specialization is really not new. In the frontier days of West Texas the cow man was always takin' pot-shots at the neighbor who raised sheep. We got our idea of specialization as a kid back in the Piney Woods when we found that a coon dog that would mess with a skunk wasn't worth shootin'. There's a special way to split a stick, too, if you want to put a possom's tail in the crack. Specialization's a good thing, and we're all for it. We live by it. We specialize in the pipe line business, and we go further than that. We're almost in the same category as the foot doctor who won't work on nothin' but left big toes. We don't make pipe, don't bend it, don't dig ditches for it, don't string it nor lay it. We don't make pipe winches, booms, cradles, saddles, Holiday detectors or any other pipe line accessories. We just protect pipe for long life, trouble-free service by cleaning, priming, coating and wrapping it. At that, we admit we're good. We've been doing this specialized job for more than a quarter century. The woods are full of our satisfied customers, but we could still use some more.

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sand fill level. The tank had previously been primed with di-chromate and coated with aluminum paint. After tack welding the angle-iron in place, it, too, was primed with di-chromate and painted with aluminum. Painting performs a dual function: (1) It prevents the iron from oxidizing, and (2) insulates the iron, thus offsetting electrolytic action, the latter being caused by salt air, fog, and high humidity. All iron work in the installation was treated in the same manner for similar reasons. Included in such work was the vertical anchor strips bolted to simple iron brackets, center angle band, and upper angle iron facing, the latter units all being welded to the tank. Actually, little welding was required, however, as a safety precaution, the brackets were first tack welded in place and allowed to cool. Other angles were installed similarly, thus avoiding any chance of fire or explosion from continuous welding heat.

Midway on the tank and completely circling it is an angle iron. This member provides support for the upper insulation and also provides a protective locking means for the aluminum sheeting below. Welded to the top of the tank is an angle-iron section that firmly locks the insulation and sheets in position at this point. With all iron work in place and properly painted, little difficulty was experienced in "fitting" the insulation to the tank.

Blocks were coursed vertically so the horizontal seams were staggered. To avoid unnecessary handling, the carton containing insulating material was placed conveniently to the workman (Fig. 2). As soon as a row of blocks was installed between the verticals, they were secured by a primed and painted stainless steel band much in the same manner as strapping a packing box. No attempt was made to apply great strain to the band, for its function keeps the blocks from falling outward. Bands were placed approximately on 2-ft centers.

The angle-iron center band mentioned previously is approximately 19 ft by 6 in. above the ground level. This permitted use of 10-ft stock size aluminum sheets with ample allowance for overlap. The lower tier of sheeting was merely placed vertically on the angle-iron step with each piece overlapping 1½ corrugations and then banded in place.

The second tier of corrugated sheets was secured vertically by improvised "S" hooks made from 3SH14 aluminum strips. The hooks were placed over the top edge of the lower sheet, providing bottom supoprt for the upper sheet. The upper edge of these sheets was locked under the flange of the angle iron. The 10-ft lengths of aluminum were handled quickly and easily. Painted stainless steel bands secured the sheets radially. Tank expansion and contraction were taken into consideration and provision made so the aluminum and insulation could move accordingly.

The weight of glass fiber blocks and aluminum both are considerably less than other types of insulation. Aluminum weight savings alone over galvanized sheet amount to more than 60 per cent. This proved a considerable factor in handling the aluminum on the installation and was reflected in the overall cost of the job.

Application of insulation and sheeting on the upper sections of the tank merely duplicated that of the lower cells. The work of insulating 15,000 sq ft of tank surface was completed in less than 2 weeks.

The finished job showing complete insulation and sheeting in Fig 3 indicates the non-glare embossed surface of the aluminum. Even in the brightest sunshine reflections are subdued and pleasing to the eye. The same attractive appearance will be lasting without further maintenance.

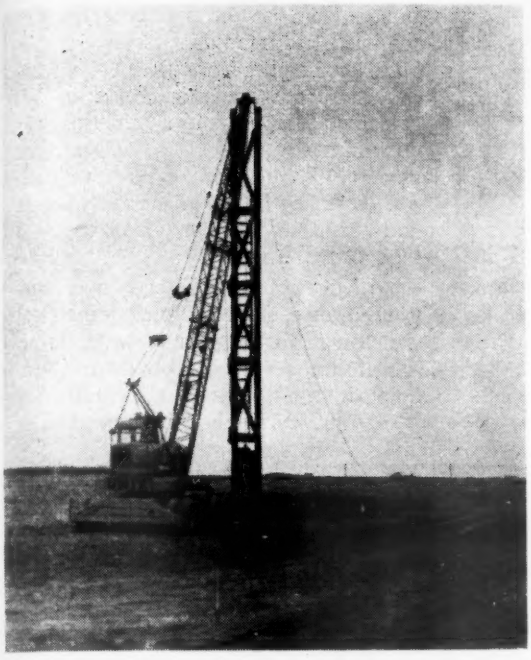
When tank inspection is necessary, it will be a simple matter to remove the binding straps, aluminum sheets, and insulation at any one-sixteenth area of the tank. The material is set aside during inspection or repair and then replaced without loss or trouble.

Effectiveness of this insulating method is shown by the following temperatures. The uninsulated tank dropped 10 F per day under normal weather conditions, and required 48 to 72 hours to heat; also steam was used continuously. The insulated tank dropped 1 F per day and required less than 24 hours to heat. Furthermore, steam may be shut off for 8 to 12 hours after pumping temperature is reached. This results in substantial operating cost savings in addition to steam savings.

Summary

It should be stated that the cost factor in the San Pedro area may differ from that in other localities. This is directly reflected by the local labor cost, cost of material, transportation, etc.; however, it is a simple matter to make comparison for it is assumed that the same savings will apply for similar insulating jobs. * * *

The Kentucky Colonel always closed his eyes when he took a drink. One day someone asked him why, and he explained: "The sight of good likkah always makes mah mouth watah, and Ah don't want to dilute mah drink!"



Pile driver on site at Gretna, Manitoba, station extension being constructed for Interprovincial Pipe Line Company.

Soils that can't support weight of stations and equipment are problem on Canadian pipe lines; driving deep piles that support reinforced concrete slabs is solution

Piling Firms Up Foundations for Interprovincial Stations, Tanks

L. O. ROWLAND

FIGHTING battles with water on the surface of the ground is nothing new to pipe line construction spreads working in Manitoba and eastern Saskatchewan, Canada, but the summer of 1954 renewed acquaintance with the perennial problem of water below the surface, combined with quicksand, when special construction crews tackled the job of building pumping station extensions at Glenboro and Gretna, two of three Manitoba stations on the Interprovincial Pipe Line Company's main line.

Ground conditions were different at the two stations, but both presented the same problem; how to place foundations that would not move under the weight of the superstructure or shift with the spring heaving of the ground and the alternate swelling and shrinkage caused by moisture conditions in the summer. At Glenboro, the soil structure is very soft clay, which is particularly susceptible to shifting or sinking under weight. The Gretna soil is stratified, wth quicksand layers and water channels intermingled, providing no base for a foundation as they occur within 3 to 4-ft of the surface.

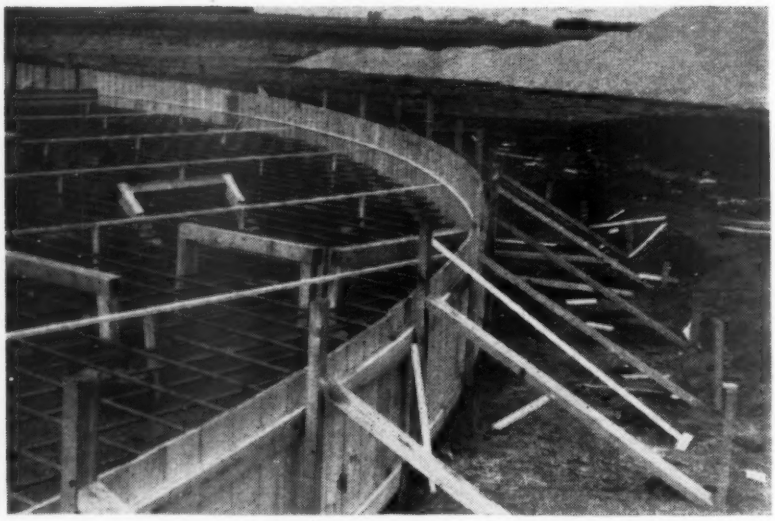
Approximately 35 ft below grade occurs a layer of "blue clay," which is practically impervious to water, well compacted, and homogeneous, and has a bearing strength sufficient to support the concentrated weight of the brick, concrete and steel station building with its pumps and engines, as well as the tankage outside. No specific data are available on the bearing strength, but it is significant that no shifting or settlement has occurred in 4 years since the stations were built on foundations laid in the same manner as those which have just been completed this summer.

The basic method of establishing foundations is to drive 40-ft piles to refusal depth, at close intervals and in straight lines along both axes of the rectangular building. At both stations the building extensions are 112 ft long by about 50 ft wide, designed to accommodate 3 new engines and pumps, of which 2 are to be installed immediately and foundations poured for the third as reserve capacity. In the case of new tankage to be provided, the 3 tanks for each station are 104 ft diam. Each has been piled with 492 piles, also set in straight lines.

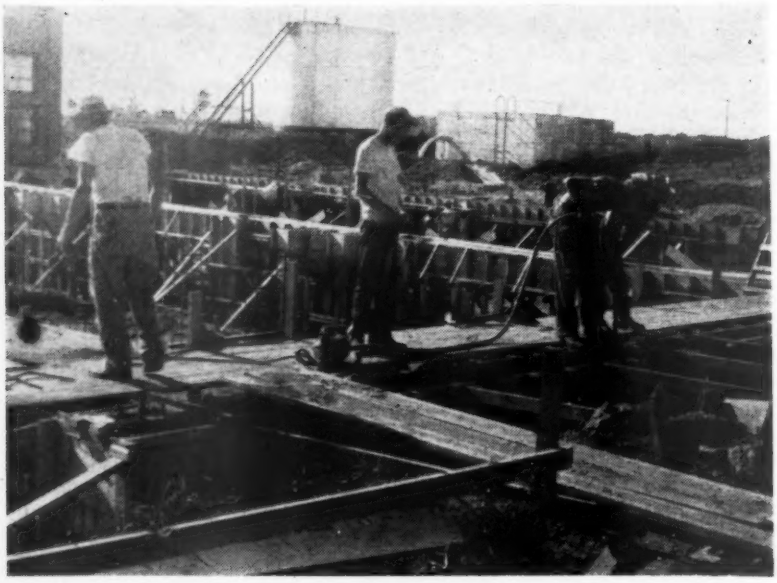
The piles were bought in British Columbia and treated with creosote in the Calgary, Alberta, plant of Canadian Creosoting Company, Ltd. They are 12-in. diam at the butt, with a slight taper which facilitates driving. Two 3½-ton steam hammers were used on each job, with average capacity of 120 blows per min and maximum somewhat higher. The contractor admits it was "tough driving," with refusal depth in a few instances being a matter of judgment as one pile broke the hammer and caused an expensive repair job. Steam was generated in on-site

EXCLUSIVE

Gravel fill being worked into tank base. Cut piles are in foreground.



Form for tank slab, reinforcing steel in place and ready for concrete pour. Piles can be seen beneath steel gridwork.



Pouring foundation superstructure walls on Cromer station extension of Interprovincial Pipe Line. Expansion will give line added capacity.

boilers, feeding through hose lines to the truck-mounted drivers.

After the piles were driven to refusal depth, an average height of 3 to 4-ft remained above ground and this was cut off to about 12-in. by gasoline powered reciprocating hand saws, each one requiring only one man to operate and furnishing a neat, clean cut at a high rate of speed.

Gravel fill was spread over the ground, to protect the reinforcing steel skeleton from the ground water level. A reinforced concrete platform 18-in. thick was then poured as a continuous monolithic spread at high speed. The tanks were foundationed with a flat slab, while the station foundations required wall rising a few inches above the slab.

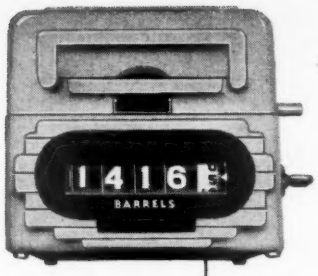
Aggregate for the concrete work was brought in from the nearest available gravel pits with suitable type of aggregate. In the case of the Gretna station the pits were located at Bird's Hill, 15 miles northeast of Winnipeg and approximately 100 miles northeast of the station site. Gravel was all moved by rail to the siding in the town, half a mile from the station, and hauled by truck to the mixing site. The mixed concrete was hauled to the foundation sites by buggies with 6 cu ft capacity in a streamlined operation which in every case resulted in a complete pour within one rather long working day. Crews generally worked a 6-day week, to make up for complete suspension of operations for several days at a time during an unusually severe rainy period in May and June.

The heads of the piles extend up 6-in. into the concrete slab, to provide a solid bond and also to prevent as far as possible the absorption of any ground moisture through the end of the timber.

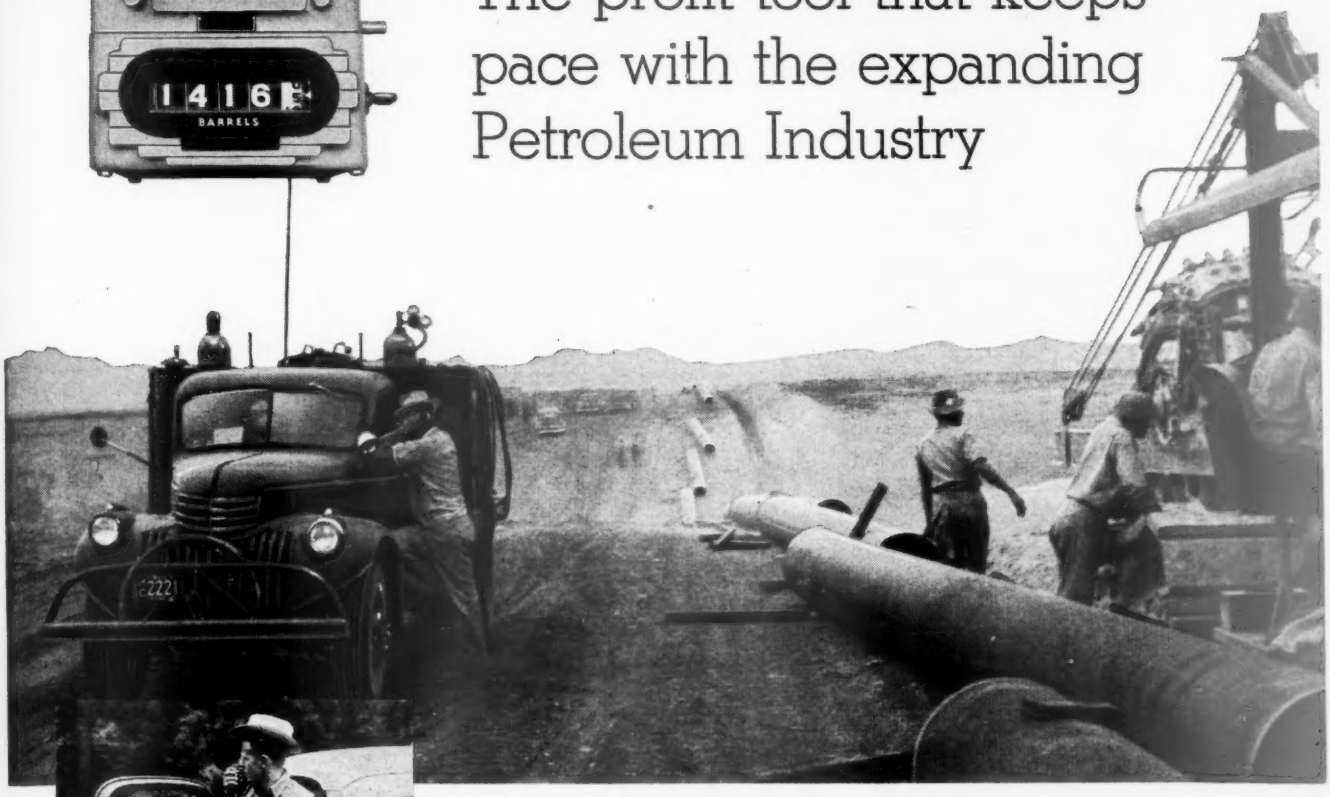
Engineering specifications and design were done by the Interprovincial engineering staff, under direction of Roger Clute in Edmonton. The general construction contract was let to Bird Construction Ltd. of Edmonton and Winnipeg, and the piling contract was handled by Macaw & Macdonald of Winnipeg, an engineering and construction firm which did a similar job on the Hardisty station in eastern Alberta when it was built in 1950. Arthur Macaw was general superintendent.

The Gretna station, it should be mentioned, is a historic structure, as the site on which it is located was under several feet of water in the Red River flood of 1950, and it was necessary to fill the site to a height of 7 ft to ensure that the station foundations would be above the flood level of that year, highest in the history of the Red River Valley. ★ ★ ★

XUM



The profit tool that keeps pace with the expanding Petroleum Industry



On a remote strip of pipeline, a road superintendent exchanges some critical information with his spread foreman some 22 miles away saving several hours delay of another complete work unit.

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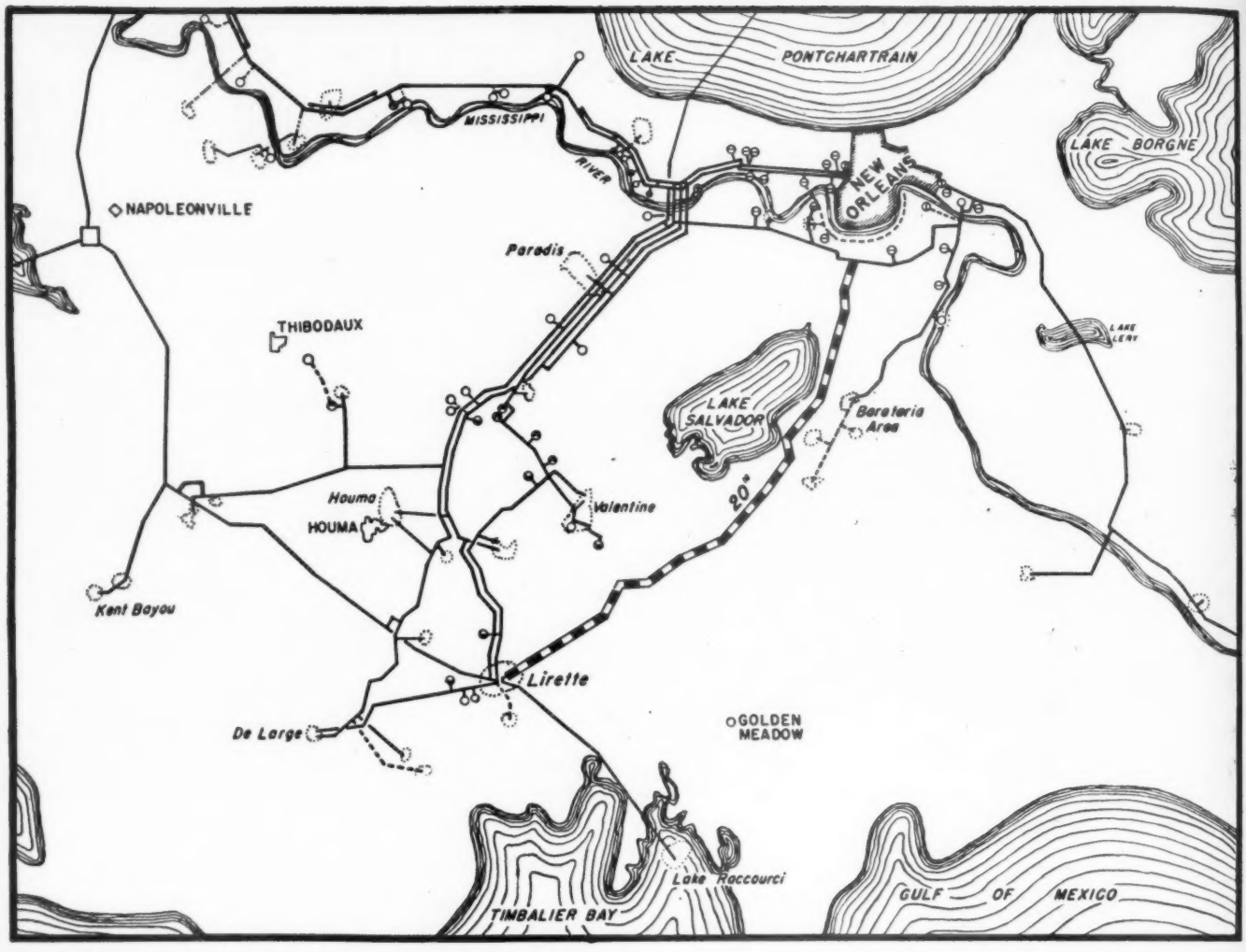


Map shows route of 20-in. line between Lirette and New Orleans.

Building a 44-mile, 20-in. line through South Louisiana for United Gas Pipe Line, semi-marine construction forces faced some of the . . .

World's Toughest Pipelining Terrain

ACROSS the marshlands of South Louisiana, through some troublesome but familiar pipelining country, United Gas has built a 44-mile pipe line to strengthen its Lirette-New Orleans system that delivers gas into the greater New Orleans area.

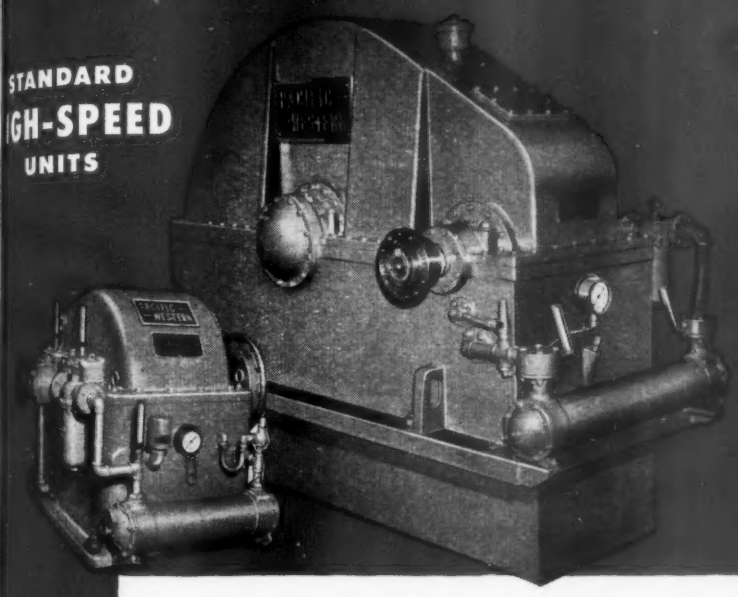
The new extension is a 20-in. lateral that extends from a point on the existing Lirette-New Orleans line near the Lirette field, located a few miles from the Gulf of Mexico, northeast to a point on United Gas Pipe Line Company's existing facilities near the city of New Orleans. It will help meet the increasing fuel demands of the New Orleans market area, including those of the Kaiser Aluminum Plant which now ranks as the largest aluminum reduction plant in the United States and the second largest in the world.

Terrain encountered by semi-marine construction forces along the route included marshes, cypress swamps, and cane fields of Terrebonne and Jefferson parishes, long recognized as some of the world's toughest pipelining terrain.

Of the 44 miles involved in the construction of the new line, only a small portion could be negotiated by conventional pipelining methods. Most of the line was laid either in canals dredged along the right of way or in ditches dug by draglines where the ground was solid enough to support heavy equipment.

Working mostly from barges and push-ramps, contractors' forces completed the 40 miles of the project early last November.

Beginning at a point on United's ex-



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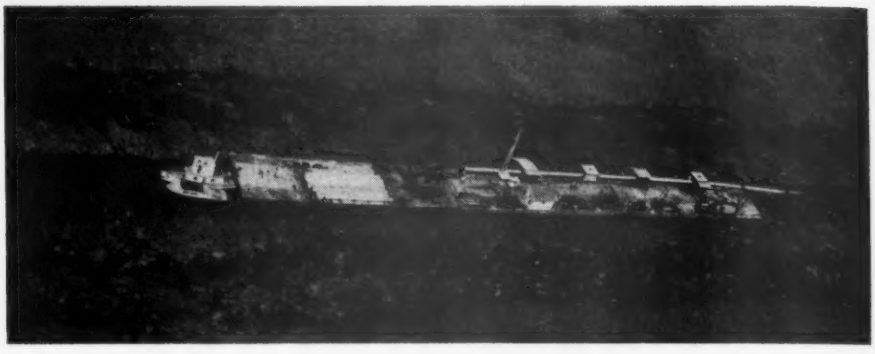
Dredges at work digging canal through marshy South Louisiana country.



Aerial view of pipe laying barge churning across marshy terrain behind dredges.

isting Lirette-New Orleans line in Terrebonne Parish, the new line extends in a generally northeasterly direction across the marsh and passes just south of Lake Salvador before turning north toward a junction with United's existing facilities near New Orleans.

The 20-in. OD, 5/16-in. wall pipe for the project was coated at Harvey and moved by barges down through a network of canals and inland waterways to the job locations. A 5/8-in. coating of somastic was applied to the entire 44 miles of pipe, and on all but approximately 3 miles, a heavy jacket of concrete with a minimum thickness of 1 7/8-in. was added to give the pipe sufficient anchorage.

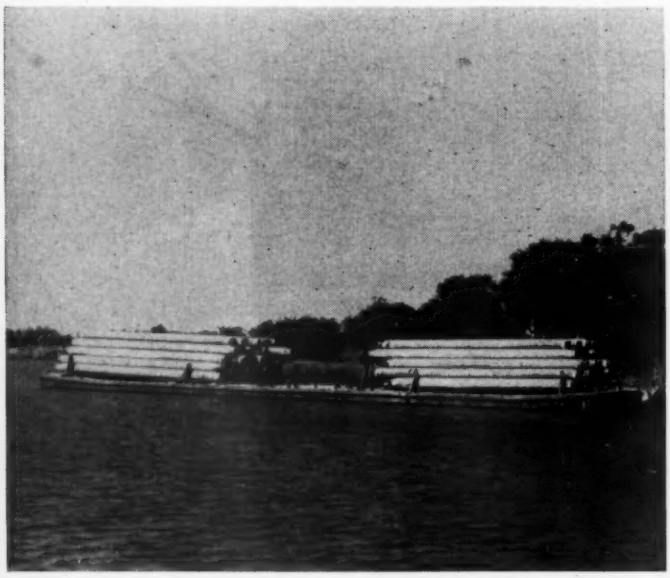
The original 5/16-in. wall pipe weighed approximately 65 lb per lineal foot. With the added coatings, it weighed slightly over 235 lb per lineal foot on the concreted portion when ready for laying.

The marsh country is a maze of canals and other waterways, and the new 20-in. line crosses more than a score of them along its course, including 5 major streams. Largest is the Intracoastal Waterway, an inland shipping lane that intersects the pipe line route about 16 miles southwest of Harvey Junction. Heavy ½-in. wall pipe with added coatings of somastic and concrete was used on all crossings.

The line was laid in 2 sections. The west end, approximately 17 miles long, extends from Lirette to the banks of Bayou Lafourche, and the other segment reaches east from Lafourche to the terminus in Harvey Junction.

Laying operations consisted primarily of pushing long sections of pipe into the swamps from barges and push-ramps, and stovepiping other sections joint by joint from the laying barges.

Concrete-coated pipe was used on all but approximately 2000 ft of the 27-mile section between Bayou Lafourche and Harvey Junction, and all but about



Pipe was coated and wrapped at yard, moved by barge through bayous and canals to job site.

Close-up view of heavily-weighted 20-in. pipe running off rear of pipe laying barge.

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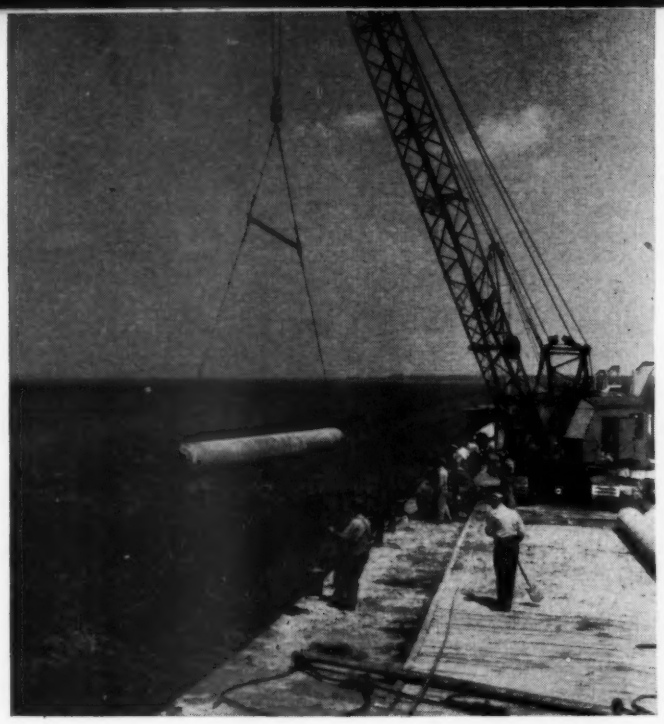
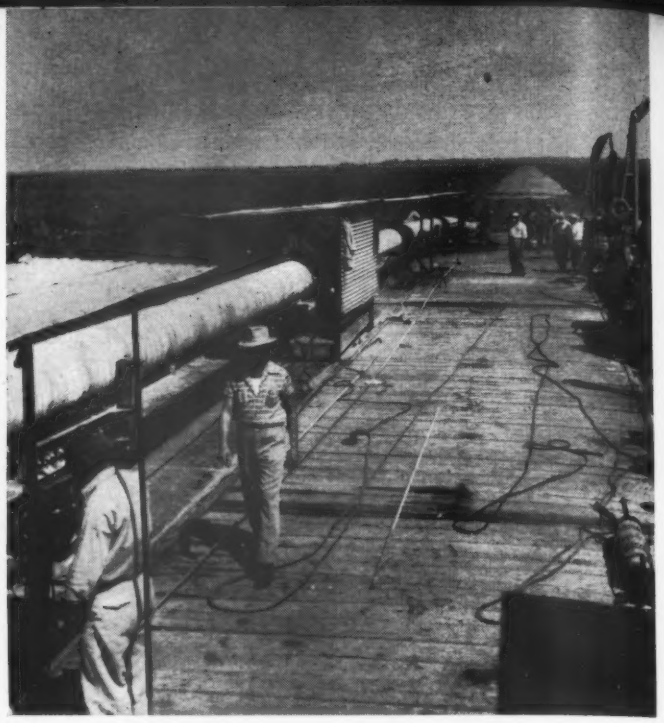


Crane picks up joint of concrete-coated pipe aboard barge, swings into place for welding.

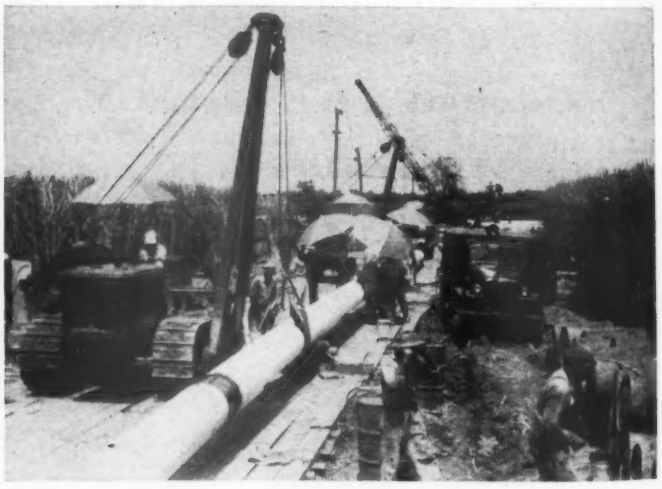


Pipe was stove-piped joint by joint on barge, field coated and lowered from barge.

Lining up section of pipe for welding on one of several push ramps used during job.

Buoys are attached to long pipe string ready to be shoved out into the swamps.

Welding joints of Somastic-coated pipe in cane field along right-of-way.



Tractors working on specially erected push ramps prepare to shove a section of pipe.

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... today's most advanced shovel-crane control system

Speed-o-Matic hydraulic clutch piston automatically self-compensates for normal lining wear and heat expansion. Weeks and in some cases months may pass before clutch adjustment is necessary. Less maintenance means more output per day.

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Yes, only Link-Belt Speeder offers you true power hydraulic control on shovels, cranes and draglines. It's the famous Speed-o-Matic control that can boost your daily production output as much as 25%!

It's one of *many extras* that are standard equipment on every current model Link-Belt Speeder, which makes it the most advanced line on the market today. You'll find all the facts on Speed-o-Matic in this new Bulletin No. 2424. For your copy, see your nearest distributor, or write direct.

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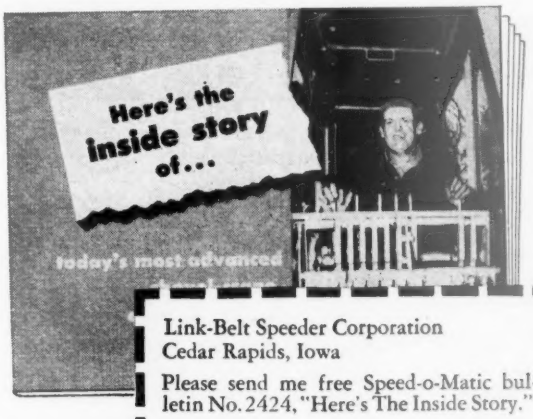

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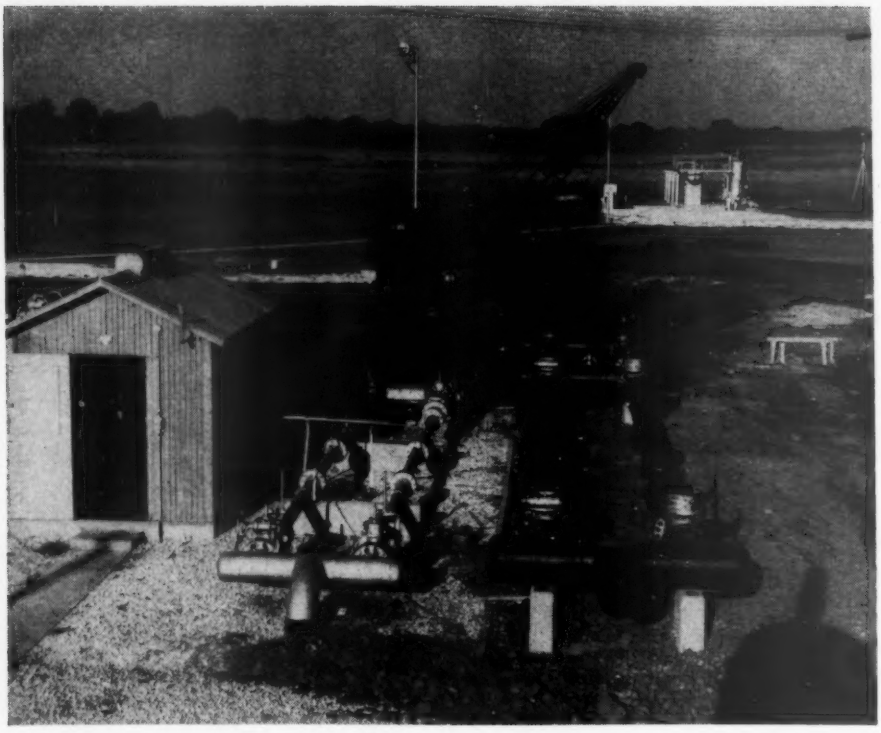


Changes at Lirette station included check meter and scraper trap installation, shown under construction here.

12,000 ft of the stretch between the existing Lirette-New Orleans line and Bayou Lafourche.

In the extremely marshy areas, it was sometimes necessary to dredge canals which in some cases were as wide as 40 ft. In areas where the ground was firm enough to permit the operation of heavy equipment on steel mats, dragline ditch was dug and the pipe shoved in from barges or push ramps. Of the 44-mile total, it was necessary for approximately 32 miles of the line to be laid in canals and about 11 miles in dragline ditch.

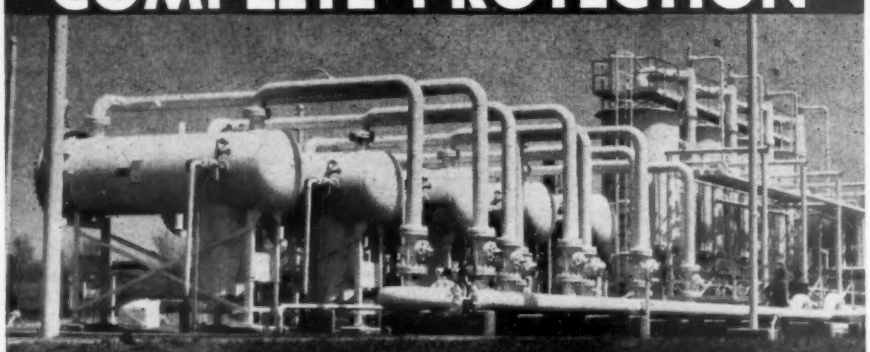
Twenty-seven miles of canal excavation was made across the swamps, and about four miles of existing canal that could be used was cleaned out. Minimum width and depths were dredged to provide ample flotation for the pipelaying barges that followed. In the canals a "pipe pocket" was dug in which the line was laid.

In some instances, pipe was welded into long sections, buoyed with drums, and then shoved into the swamp from push-ramps. When the section reached location, the buoys were cut loose to allow the line to sink down into the swamps. In other areas pipe was welded and laid, joint by joint, from work barges operating in the canals.

The longest single shove, consisting of a 9277-ft section, was made from a push-ramp and pushed into dragline ditch. The longest shove off a barge involved approximately 8800 ft of pipe.

In addition to main line construction, the project also necessitated a considerable amount of yard work. This included check meter and scraper trap installations at Lirette, and scraper trap, separator, and meter installations at Harvey. * * *

COMPLETE PROTECTION



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P 616.05

Cold, muskeg swamps, permafrost, mosquitoes —

"Unusual" Describes Alcango Pipe Line

THE statement, "in Alaska, the unusual is usual" certainly applies to the current construction of the 625-mile 8-in. "Alcango" military products pipe line from Haines to Fairbanks by Williams Brothers Company of Tulsa, Oklahoma.

Even before clearing started, the unusual was happening. Williams Brothers had ordered a package of tractor equipment to aid in the pipe line construction, and decided the entire order would be shipped by water from Peoria, Illinois, to Alaska. This shipment was unusual in the fact that it traveled 8000 miles by water to reach its destination in United States territory on the North American continent.

Clearing the right-of-way for the Haines to Fairbanks pipe line began in mid-December of 1953. The clearing work was done by Oaks Construction Company under sub-contract. A crew of two dozer-equipped tractors started the operation clearing brush on Birch Hill, a point in Ladd Air Force base, near Fairbanks.

With only three hours of sunshine daily, the crew pushed hard. A one foot blanket of snow covered the rock-hard frozen ground. The tractors had slow going but brush and small trees were cut off clean.

On January 1, 1954, two more crawlers were brought on the scene. Each worked in the opposite direction out of Tok, and another worked from the Canadian border near Scotty Creek, toward Fairbanks. Crews cleared about a mile per day each.

During February, the temperature nose-dived. There were 15 days out of that short month when the thermometer read from minus 30 to minus 60 deg. During the cold spell, only one crew worked. This two-tractor unit, under the supervision of Slim McMahon, had a unique system for keeping operators warm. The operators were covered with tarps so that the heat of the engine would be directed on them. At night, the entire tractors were covered with tarps weighted down with large rocks. Eight No. 2 kerosine lanterns maintained sufficient warmth under each tarp to make starting of the tractors easy in the morning. No unusual trouble occurred during the cold snap, and no breakage was noted.

After the weather took a turn for the better, five crews continued to clear and drain previously cleared land after the thaw. Each crew was able to cover approximately 2½ miles daily.

At present, there are still 2 crews grading, one about 250 miles from Fairbanks and the other 25 miles farther toward Canada. The distance from Fairbanks to the Canadian border is 300 miles.

The 625 mile route from Haines to Fairbanks traverses some of the roughest going on the North American continent. Mountains, swamps, muskeg, and river crossings are all major problems. But one of the things that makes life really interesting on this job are the mosquitoes. There have been three distinct crops. First came the large, super giant size followed by two smaller varieties, both excellent biters.

EXCLUSIVE

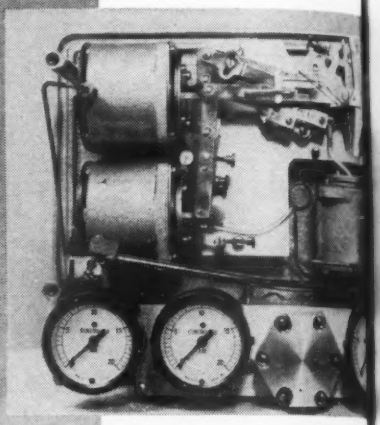
In the words of Red Davis, general superintendent for the contractor, "When you lay a pipe line in Alaska, the unusual is usual."

On April 1, all equipment for the Alaska section arrived at Valdez on the "Henry Stevenson." Included were 40 miles of pipe, all trailers, camp equipment, tractors, welders, etc. The pipe was hauled by Alaska Transport Company over the Richardson Highway from Valdez to Fairbanks and stockpiled every five miles along Alaska Highway.

Hauling the 8-in. pipe was no easy task. Over 60 miles of the Richardson Highway is gravel, and the spring thaw necessitated a road block from April 25 to May 13 when no loads were hauled. The road traverses many narrow bridges and there are some rather winding sections to navigate, but no time was lost. After May 13, full loads of 40 joints (40,000 lb) were moved northward from Valdez.

The first camp, 16 miles from Fairbanks, was set up 2 days after the equipment was landed. All camp equipment is highly mobile. Spartan trailers, brand new, serve as sleeping quarters for the men. Power and lights for the camp are furnished by a diesel electric set. At present Williams Brothers have 2 mobile camps, housing approximately 200 men on the Alaskan section. The majority of all welders, foremen, and boom tractor operators are from the states, particularly the southwest, many being from Texas.

The 1954 summer has been unusually wet in the area, especially the last month, but none of the crew forget



Interior view of Ratio R shows simple, compact struction. Pressure gages cate input signals and pressure. Adjustments for trol action, zero setting ratio range are readily sible.

The Tel-O-Set Ratio Relay offers these unique features:

★ **LINEAR RATIO**
Output changes in straight-line relation with primary variable. Permits better control tuning . . . eliminates "compromise" settings.

★ **DIRECT OR REVERSE ACTION**
Readily set to provide either increasing or decreasing output . . . increasing or decreasing ratio.

★ **FLEXIBLE ADJUSTMENT**
Ratio range can be reduced to any desired value. Reduced span can be positioned at any desired portion of the maximum range. Factory setting is 50—150% ratio range.

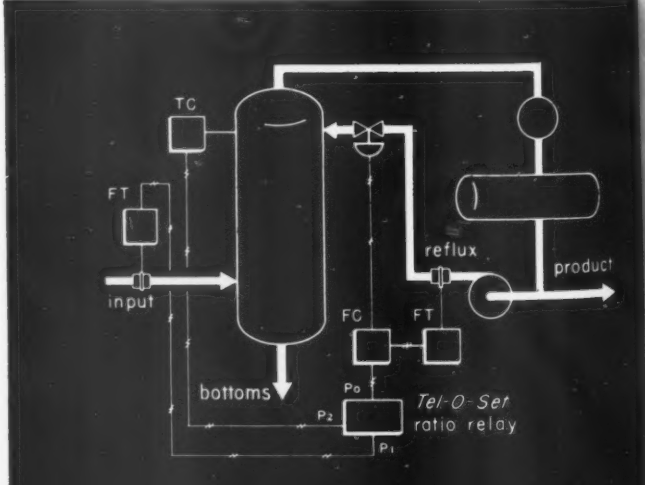
★ **WIDE RANGE**
Ratio can vary from 0 to 200% for a full scale change in the primary variable.

★ **ADJUSTABLE LIMITS**
Readily set stops are provided to limit minimum and maximum output pressure.

★ **ZERO SUPPRESSION**
Independent zero adjustments permit selection of the exact input-output relationship desired.

★ **INDICATING GAGES**
Separate indicators show output pressure and both input pressures.

On a distillation column, Tel-O-Set Ratio Relay receives air signal (P_2) from column temperature controller. This signal varies the ratio of the output pressure (P_0) to the signal received (P_1) from the input flow transmitter. Output pressure feeds into an *Indexet* remote setting index in the flow controller, to reset this instrument and thus throttle the valve in the reflux line. Ratio of reflux to input is thus varied in accordance with temperature of the top of the column.



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New, versatile means for effecting cascade control

the Tel-O-Set Ratio Relay

HAVE a complex control loop? Here's a versatile way to simplify it . . . the new *Tel-O-Set* Ratio Relay. Another advanced idea in process control from Honeywell, this unique relay proves the ideal solution to complex cascade control problems.

The Ratio Relay provides automatic control with a single element influenced by three interrelated variables. For example, it is used on distillation columns (see diagram) to control the ratio of reflux to feed, as column temperature varies. In absorption towers, it regulates ratio of absorbent and feed stock to give constant concentration of product. And there are scores of other uses for this relay . . . in evaporators, controlled-atmosphere furnaces, reaction tanks, engine testing and other applications where several related variables must be interlocked for efficient operation.

The Ratio Relay receives pneumatic signals from remote transmitters, controllers or manual loading stations. It produces an output air signal for readjusting the set point of a secondary controller. It is the ideal companion for Honeywell Differential Converters, *Tel-O-Set* miniature instruments and Brown pneumatic controllers.

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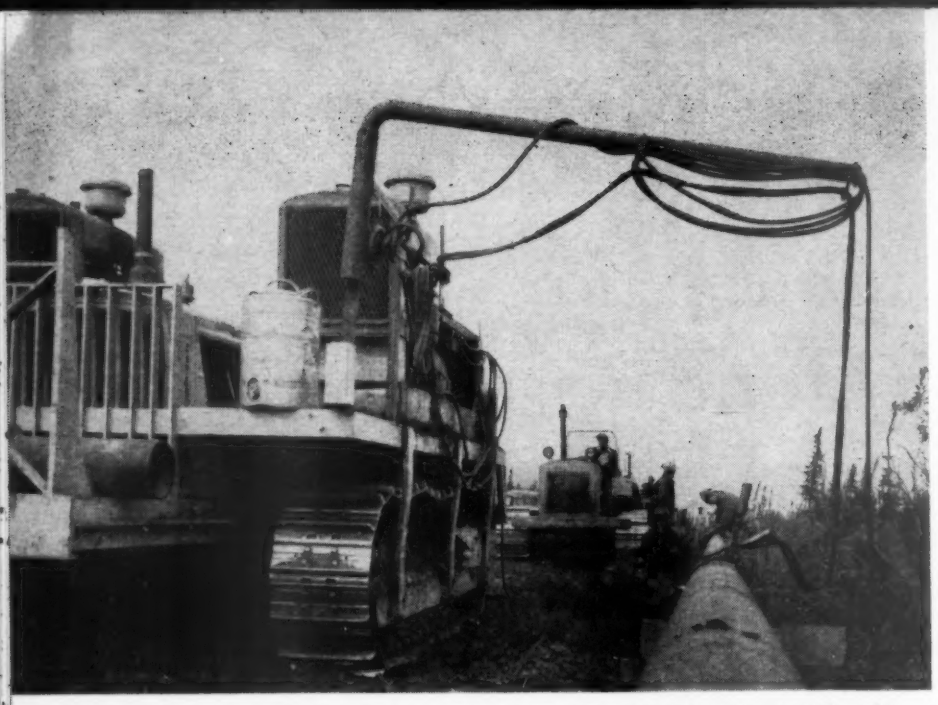
BROWN INSTRUMENTS

First in Controls



Top. Tractors rigged with welding equipment made traversing tough terrain easier.

Center. Clamshell, with "long reach," helped lower-in pipe where going would have been difficult for tractors.

"Muskeg" weights were used in swampy country. Boom-tractor here helps place weight in place on line in ditch.

April 29. That's the day the first boom tractor and jeep went through the ice. Only 5 ft of the 22 ft boom stuck through to mark the spot. Evidently there was water below the 18 in. of ice. Luckily, the operator had shut off the engine and jumped to safety. When the machine was recovered with the aid of two other tractors, it was flushed out, inspected, and put back on the job with no more damage than a badly bent boom. Later, another tractor went down with the engine running and suffered 5 bent rods. This one is back on the job too.

Grading the 50 ft right-of-way started April 1 at Fairbanks, and stringing pipe commenced April 13. Just 6 days later, on April 19, the first welding began and 150 joints were fastened that first day. On July 22, 536 joints were laid up. The welders averaged 2 miles per day, but more recently have been laying 4 miles per day.

Another most unusual aspect of this job is the fact that there are five sets of inspectors on the job. Not only is the best welding ever done on a pipe line being accomplished, but the best inspected also! Close inspections are made by the following teams: (1) Army Engineers, (2) Civilian Army Engineers, (3) District Engineer from Anchorage, (4) Civilian district Army Engineer and (5) Contract Isotope.

Five different welders work on each welded joint. There is no doubt that inspections are a major job and cutouts are many. These welders are all experts, but the inspection is rigid to meet the unusual weather requirements.

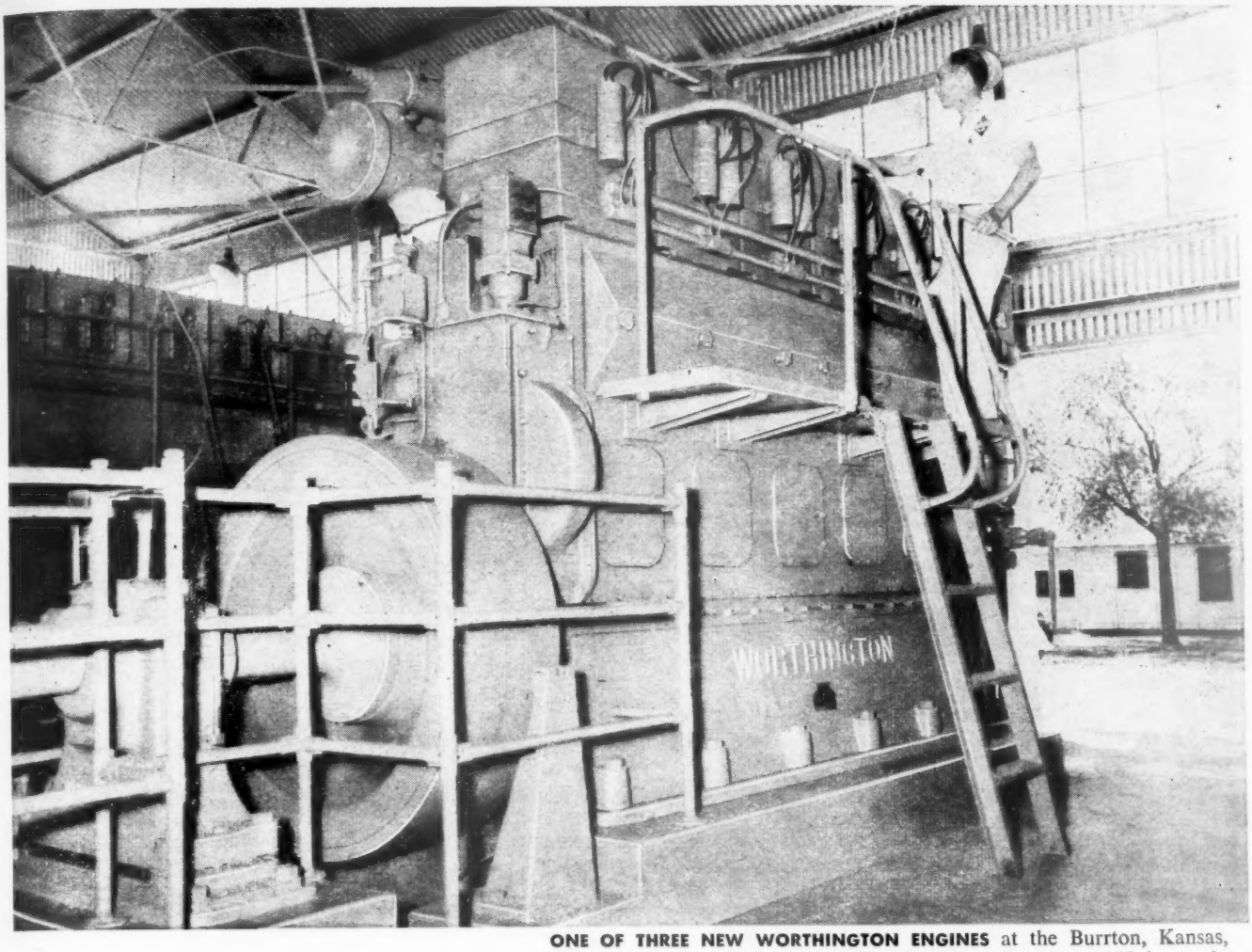
After final inspection okay's everything, a wire pig is run through the line for cleaning the inside of the pipes, and another rim pig goes through to check clearance. Air pressure, 125 lb psi is maintained for 24 hours between gate valves.

No coating and wrapping was used on the pipe. Standards determined by the Corps of Engineers, who designed the line, said the soil in the line's area is not corrosive. Approximately 70 miles were buried, the balance laid above ground.

Total pipe laid in Alaska so far, all complete except for bridges and underwater crossings, is 175 miles. The pipe line crosses the Alaska Highway 8 times between Fairbanks and the Canadian border.

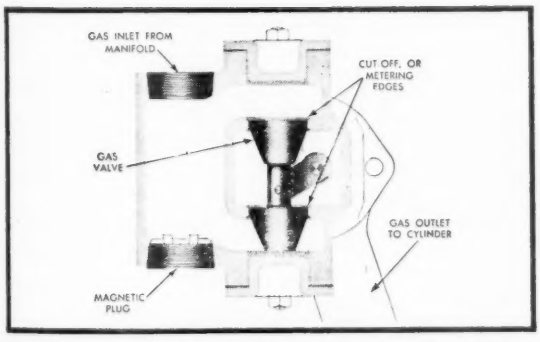
In the maneuver area around Ladd and Eielson Air Force bases, 110 miles of this new pipe line is buried as is a 40-mile section from Haines, north. The balance of approximately 300 miles of the Alaska section will be above ground.

Ninety per cent of the route is tough going. The ridges are comparatively easy going, but on the high ridges, per-



ONE OF THREE NEW WORTHINGTON ENGINES at the Burrton, Kansas, pumping station of the Skelly Oil Company. Rated at 445 hp each, these engines drive centrifugal pumps through step-up gears.

Skelly Oil buys three more Worthington engines



MICRO-METERING GAS VALVES used on all Worthington spark-ignition and dual-fuel engines assure equal cylinder loading, smooth running at all loads, better speed regulation, and lower maintenance.

You find out a lot about the performance of engines when you live with them 16 years.

Skelly Oil Company had that long to assess two Worthington gas engines installed in 1936 in their old pumping station at Burrton, Kansas. Driving centrifugal pumps through step-up gears, the Worthingtons did a fine job in moving crude oil 52 miles to the Skelly refinery in El Dorado. So when the time came to rebuild the Burrton Station with enlarged capacity, Worthington engines again received the nod from Skelly engineers.

Repeat business like this isn't exactly a surprise to Worthington. But it's still good to know that our old customers — people who have given our engines a real workout for years — keep coming back to us for additional equipment. Let us help with *your* power problems — write Worthington Corporation, Engine Division, Section E.4.6, Buffalo, New York. E.4.6

WORTHINGTON

Economical, Continuous Power — Diesel, Dual-Fuel and Spark-Ignition Engines, from 200 to 5000 bhp.

XUM

Left, stringing crew at work on best section of the entire 625-mile line. Two-tractor, one truck crew handled 680 joints in 10 hours here, 25 joints to a truckload. Right, pipe ends were buffed with tractor-mounted power unit, preparatory to welding. Note the home made lifting arm attached to arm of tractor bucket.

mafrost is found on the shady sections. It's an established fact that there is no tougher digging than permafrost, except glacier and solid rock.

Some pipeliners have for years maintained that "you can't dig permafrost with a ditcher." Williams Brothers, however, must not have heard of this saying, for ditching on this military products line was accomplished with a revised ditcher. A few changes were made; a smaller heavy duty wheel was used and two more "jiffy" buckets were added (making a total of 14). Five and six-inch rooter teeth were placed alternately on each bucket.

It's a slow process, but the rooter teeth keep chipping away at the permafrost. After a bit, there's more ditch than was there before, and soon these patient men move ahead. A set of new teeth is used every shift. A lead crawler tractor with 300 ft of ⅞-in. cable has helped drag the ditcher from Fairbanks.

A typical spot where the ditching crew works is in huge muskeg swamps. At a glance it looks like a soft touch, but what a place to work! About a foot down through the moss-like muskeg and grass is the tough permafrost. In some spots the frost is 30 in. down.

The muskeg swamps are considered the toughest part of the whole project. The crawler tractors can proceed slowly if they keep going. It takes skillful operators to keep from miring down. Once a tractor slips through the soft upper-layer, it bogs down on the frozen ground below. In this mess, the men are ditching 3500 ft in 24 hours.

Boom equipped crawlers bring in river clamps (cement blocks weighing 480 lb per set). Muskeg blocks have the same weight and have an eye hook for ease in handling.

When the ditcher dumps the permafrost to one side, the ice soon begins to thaw producing the finest batch of slush imaginable. This slush, coupled with the swampy muskeg, makes for extremely difficult crawler operation. But if it's tough for a crawler to operate in, imagine the pipeliners, on foot, sloughing through 24 hours a day!

Superintendent Davis explains that this particular job was extremely well planned, and that the going is no tougher than was expected. Williams Brothers pipeliners are operating according to schedule — on schedule. There isn't the shadow of a doubt in any of the minds of the pipeliners that the job will be completed on schedule during the summer of 1955.

The contract for the Haines to Fairbanks pipe line was bid by a joint venture consisting of Williams Brothers, McLaughlin, Inc., of Great Falls, Montana and Marwell Construction Company, Ltd., of Vancouver, British Columbia.

Pipe line work was sublet by the joint venture to Williams Brothers; pump stations and terminals were sublet to Marwell.

Williams Brothers sublet loading and hauling of pipe to Alaska Transport; sublet clearing and grading of right-of-way to Oaks Construction Company, and sublet feeding and housing services to Canus Services, Inc., Seattle, Washington.

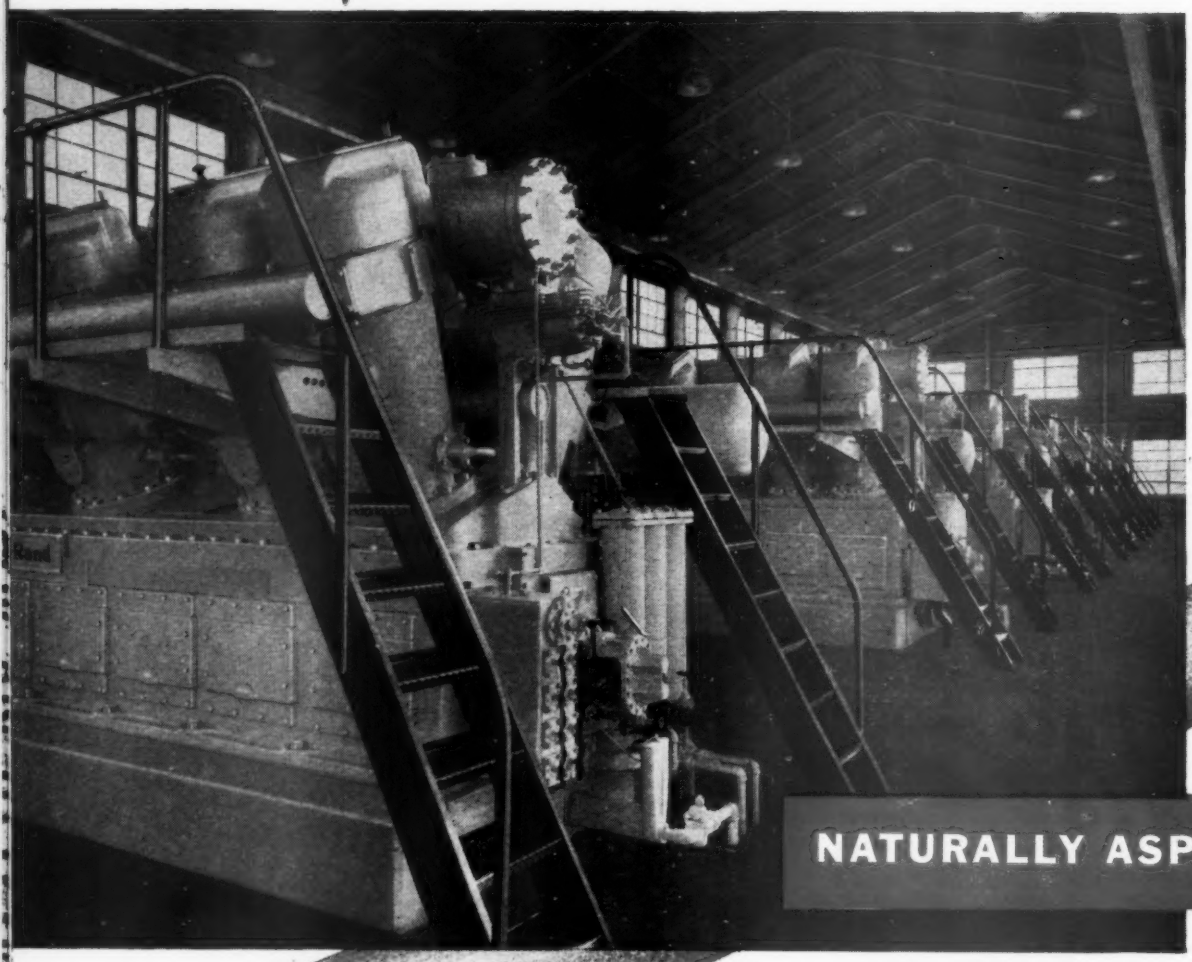
The Canadian portion of the pipe line construction was sublet by Williams Brothers to Williams Brothers Corporation (Canada), Ltd. Alaska Transport, Oaks Construction, and Canus Services were also subcontractors for Williams Brothers Ltd. * *

Ditcher equipped with 14 buckets and 6-in. rooter teeth chops away at permafrost. New set of teeth is used every shift. Tractor, leading ditcher by 300 ft and equipped with ⅞-in. cable, help drag ditcher over entire route of line.

PIPE LINE DEVELOPMENTS

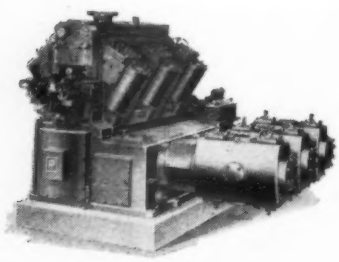
Name of Company	Miles	Pipe size, in.	Location	Contractor
CRUDE LINES				
Arapahoe Pipe Line Company	319	18	Merino, Colorado, to Great Bend, Kansas	R. H. Fulton
Arapahoe Pipe Line Company	175	20	Great Bend to Humboldt, Kansas	Fulton & Panama-Williams
Cheyenne Valley Pipeline Company	58	10	Lance Creek to Fort Laramie, Wyo.	Planned
Continental Pipe Line Company	58	8	Sussex to Glenrock, Wyoming	Proposed
Interprovincial Pipe Line Co.	129	24	Edmonton to Alberta-Saskatchewan Border	Mannix, Ltd.
Interprovincial Pipe Line Co.	124	24	Alberta-Saskatchewan Border to South Saskatchewan River	Fulton-Banister Construction Company
Interprovincial Pipe Line Co.	201	24	South Saskatchewan River to Gretna, Manitoba.	Anderson International
Kaybee Pipe Line Company	46	10	Griffith, Indiana, to New Buffalo, Michigan	Proposed
Lakehead Pipe Line Co.	153	26	Loops on present line	R. H. Fulton & Company
Lakehead Pipe Line Co.	51	26	Loops on present line	Anderson Brothers
Michi, Inc.	222	10	Highland, Indiana, to Elsie and Alma, Michigan	Proposed
Minnesota Pipe Line Co.	250	16	Clearbrook to Hastings, Minnesota.	Williams Brothers
Mid-Saskatchewan Pipelines, Ltd.	24	8	Smiley Kerrobert, Saskatchewan, Canada.	Planned
NNCW Pipe Line Co.	127	8–10	Western County to Casper, Wyoming.	Planned
Orchard Pipe Line	45	8	Orchard to Merino, Colorado.	Proposed
Pembina Pipe Line Company, Ltd.	325	3–12	Gathering system in Pembina field	Mannix, Ltd
Pembina Pipe Line Company, Ltd.	72	16	Pembina field to Edmonton, Alberta	Permit issued
Powder River Pipe Line Company	436	10–16	Williston Basin to Laure and Billings, Montana	Proposed
Proven Oil & Refining Company	32	8	Connection with West Coast Pipe Line to Florence, Ariz.	Planned
Roosevelt Oil & Refining Corp.	22	4,6	St. Helen to Norwick, Michigan.	Planned
Service Pipe Line Company	21	8–10	Near Tioga, North Dakota.	C. P. Bartley and Son
Sinclair Pipe Line Company	31	12–16	Monee to Lemont, Illinois	Proposed
South Saskatchewan Pipe Line Co.	155	16	Fosterton to Regina, Saskatchewan, Canada.	Fulton-Bannister
Trans Mountain Oil Pipe Line Corp.	26	16–20	Canadian border to Ferndale, Washington.	Engineers Ltd.
Trans Mountain Oil Pipe Line Corp.	27	20	Laurel Junction to Mt. Vernon, Washington.	Planned for 1955
Union Oil Company	65	12	Santa Clara Field to Wilmington Refinery.	Planned
U. S. Navy	450	8	Fairbanks to Gubik Gas field, Alaska.	Proposed
West Coast Pipe Line Company	960	20–22	Wink, Texas to Norwalk, California.	Planned
Western Pipe Line Company	630	20–22–24	Fort Laramie, Wyoming, to Freeman, Missouri	Planned
PRODUCTS LINES				
American Pipe Line Company	1910	8 to 26	Beaumont, Tex., to Newark, New Jersey, with laterals.	Proposed
Badger Pipe Line Company	215	8–10–12	East Chicago, Indiana to Madison, Wisconsin.	Morrison Construction Co. has Chicago area section
California-Oregon Pipe Line System	103	6	Crescent City, California to Medford, Oregon.	Proposed
H. W. Bass & Sons, Incorporated	152	4–6	Duval and Live Oak Counties, Texas, to Corpus Christi, Texas.	Proposed
Bell Oil and Gas Company	140	6–8	Ardmore to Cushing, Oklahoma	Planned
El Paso Natural Gas Company (LPG Line)	119	3–6	Bloomington to Gallup, New Mexico	Planned
Goliad Corporation (LPG Line)	117	4–6	Kittie Plant to Corpus Christi, Texas	Planned
Great Lakes Pipe Line Company	83	12	Alexandria to Rosedale, Minnesota.	R. H. Fulton
Great Lakes Pipe Line Company	80	12	Rosedale to Rosemount, Minnesota.	Associated
Inland Corporation	22	6	Springfield to Dayton, Ohio	Planned
International Pipe Line Inc.	132	8	Wrenshall to Minneapolis, Minnesota.	Proposed
Mayflower Pipe Line Company	—	—	New Jersey refineries to New England points.	Proposed
Oil Basin Pipe Line Company	230	8	Laurel, Billings to Glendive, Montana.	Midwestern
Phillips Petroleum Company	54	6	Goldsmith to Borger, Texas.	Planned
	52	10	Shell's Brookshire system to Sweeny, Texas.	Planned
Shamrock Oil & Gas Corporation	55	6	McKee to Amarillo, Texas.	Planned
Shell Pipe Line Corporation	65	12	Baton Rouge, Louisiana to Norco Refinery.	Houston Contracting Company
Standard Oil of Texas	250	6	El Paso to Albuquerque	Planned
Sunflower Pipe Line Company	265	3–6	Kearny, Grant and Haskell counties to Wichita, Kan.	Planned
Triangle Pipe Line Company	560	12	Arkansas City, Arkansas, to Covington, Kentucky.	Proposed
United States and Canadian Govts.	600	8	Haines to Fairbanks, Alaska.	Underway
U. S. Army	600	—	Network of products lines in Spain to serve military bases.	Planned
Wyoming-Nebraska Pipeline Company	215	6	Cheyenne, Wyoming, to North Platte, Nebraska.	Houston Contracting Co.
GAS LINES				
American-Louisiana Pipe Line Company	1120	22 & 30	Lowry, Louisiana to De'roit, Michigan.	Proposed
Arkansas-Louisiana Gas Company	136	8⅝ to 24	Nine Loops on System.	Approved
Arkansas-Missouri Power Company	140	2 to 10	St. Francis River, Clay County, Ark. to Campbell, Mo.	Planned
Associated Natural Gas Company	88		Missouri.	Proposed
Central Hudson Gas and Electric Company	48	12	TGT line to Kingston, N.Y.	Proposed
Cities Service Gas Company	18	16	Lawrence and Newton Counties, Missouri.	
Cities Service Gas Company	24	26	Franklin and Johnson counties, Missouri.	Approved
Cities Service Gas Company	9	20	Cherokee and Jasper counties, Missouri.	Approved
City of Fayette, Alabama	20	5	Fayette, Ala. to Southern Natural's system.	Proposed
City of Dallas, Georgia		8, 4½	Distribution system.	Engineering–Construction Company, 1954.
Coast Counties Gas Electric Company	40	3, 4 & 8	Coast and Valley Region, California.	Planned
Colorado Interstate Gas Company	365	22	Green River, Wyoming to Denver, Colorado.	Approved
Colorado Interstate Gas Company	243	4 to 20	Colorado, Oklahoma, Texas, and Kansas.	Engineering–Construction and Z. J. Graham
Colorado-Western Pipeline Co.	328	16–18	Ignacio field to Pueblo and Denver	Approved
Continental Oil Company, (Agent)	—	—	Gas gathering system in Washington and Adams counties, Colorado.	Planned by operators of Little Beaver and Badger Creek fields
Cumberland and Allegheny Gas Co.	31	12	Garrett County, Maryland, to Keyser, West Virginia.	Proposed
El Paso Natural Gas Company	74	—	Additions in Texas, New Mexico and Arizona.	Proposed
El Paso Natural Gas Company	13.3	—	Lea county, New Mexico.	Planned
El Paso Natural Gas Company	32.5	10	Reagan county to Upton County, Texas.	Approved
Fort Worth Basin Gas Company	—	—	Novice, through Brown and Comanche Counties, Tex.	Planned
Gulf Interstate Gas Company	329	12–24	Laterals off Acadia Parish, Louisiana, to Boyd County, Kentucky, line.	Proposed
Home Gas Company	32	12	Breesport to Union Center, New York.	Planned
Home Gas Company	22	12–16	Binghamton, New York.	Underway
Hope Natural Gas Company	22½	12	Boone and Logan Counties, W. Va.	Approved
Interstate Power Company	26	8	Hooppole, Illinois to Clinton, Iowa.	Proposed
Iroquois Gas Corp.	24½	20	Erie County, New York	Underway
Kansas-Nebraska Natural Gas	41	10	Albion, Arcadia, and Broken Bow, Nebraska.	Approved
Kansas-Nebraska Natural Gas	37	2–3	Gathering lines in Colorado.	Approved
Kansas-Nebraska Natural Gas	66	—	Gathering lines in Denver-Julesburg area.	Approved
Kansas-Nebraska Natural Gas	40	—	Gathering lines in Hugoton field in Kansas.	Approved
Kansas-Nebraska Natural Gas	13	—	Gathering lines in Guymon field of Oklahoma.	Approved
Lateral Gas Pipe Line Co.	27	—	Grant, Clarinda and Villisca, Iowa.	Planned
Llano Grande Corporation	130	2–26	Cochran County, Texas	Panama-Williams
Manufacturers Gas Light & Heat	40		Allegheny, Washington, and Beaver Counties, Pa.	Proposed
Manufacturers Gas Light & Heat	61	3 to 16	Various points on system in Pa., West Vir. and Ohio.	Approved
Manufacturers Gas Light & Heat	72	16–20	Doddridge, Wetzel and Marshall Counties, West Vir.	Approved
Michigan Consolidated Gas Company	25.5	12	Sparta to Muskegon, Michigan.	Planned
Michigan-Wisconsin Pipe Line Company	252	4–24	Loops and stations in Illinois.	Planned
Mid-South Gas Company	68.5	—	lines to serve eight Arkansas communities	Proposed
Mississippi River Fuel Corporation	190	10–18	Laterals in Woodlawn and Waskom gas fields, Tex.	Planned
Missouri Public Service	24	10	New Franklin to Trenton, Missouri.	Proposed
Montana-Dakota Utilities Co.	4	—	Lines and 2640 hp station in Big Horn County, Mont.	Approved
Montana-Dakota Utilities Co.	49	—	Loops in Montana, Wyoming, South Dakota	Approved

4-CYCLE GAS-ENGINE COMPRESSORS

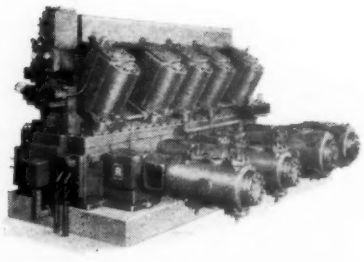


Six 1320-hp Ingersoll-Rand KVG gas-engine-driven compressors installed at a gas booster station in Texas serving a new 30-inch pipe line.

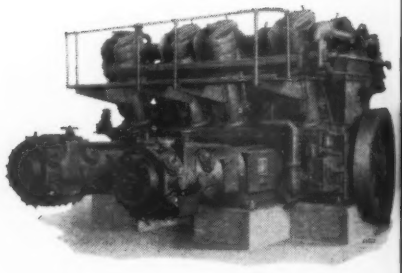
There's a Dependable IR Unit for Every App



JVG 110, 165 and 220 hp
Available with 4, 6 or 8 V-angle power cylinders and 2, 3 or 4 compressor frames.



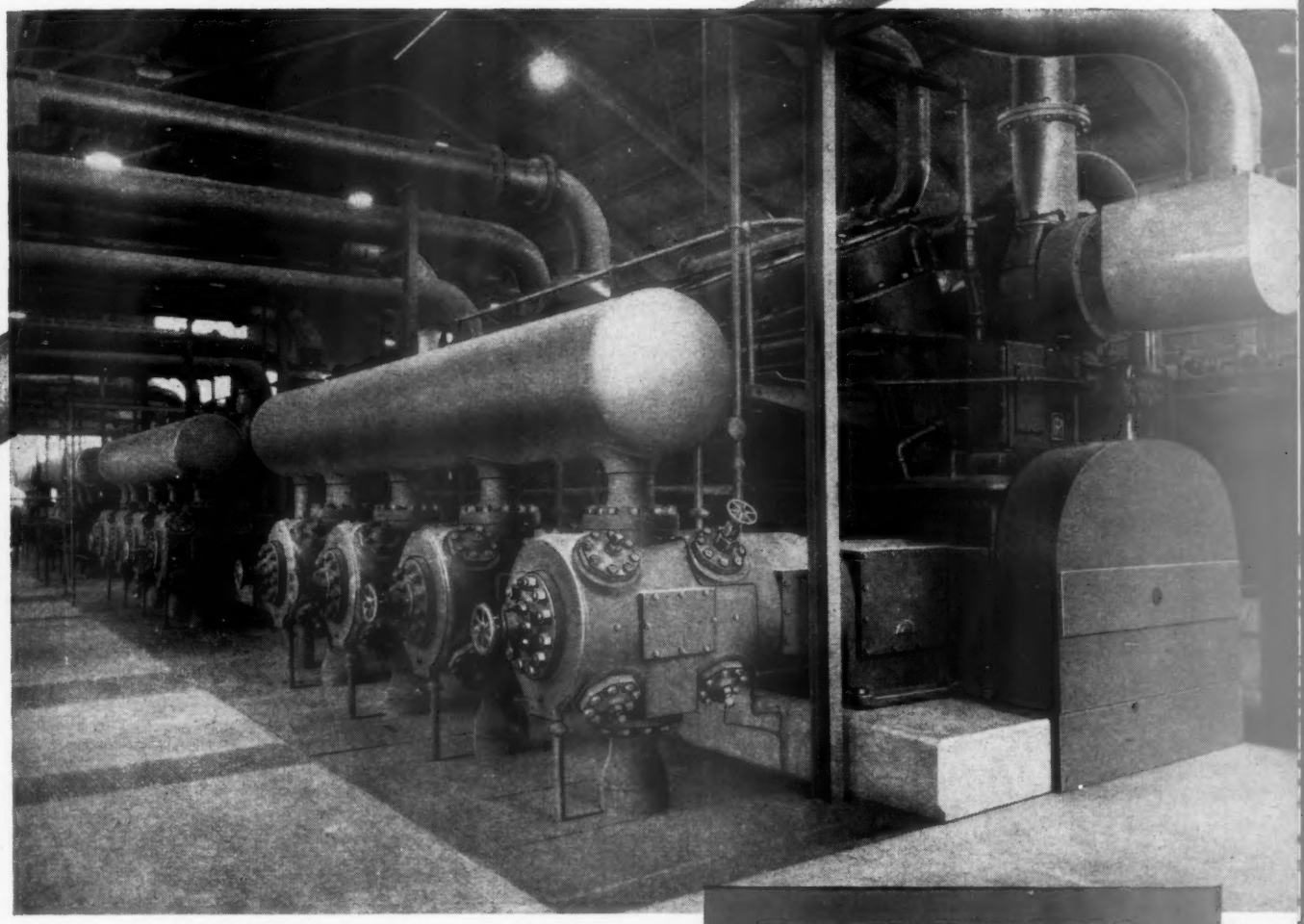
SVG 330, 440, 550 and 660 hp
Available with 6, 8, 10 or 12 V-angle power cylinders and 3 or 4 compressor frames.



KVG 660, 880, 1100 and 1320 hp
Available with 6, 8, 10 or 12 V-angle power cylinders and 2, 3 or 4 compressor frames.

Ingersoll-Rand companion 4-cycle gas engines are available to drive generators, pumps and other equipment

PIPE LINES



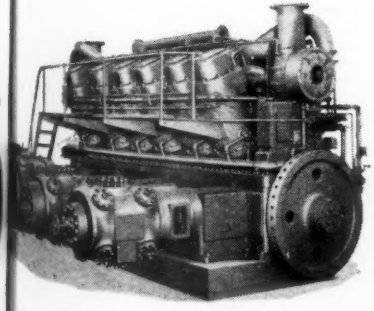
Seven Ingersoll-Rand 2000-hp KVS gas-engine-driven compressors at a natural gas pipe-line station in the Southwest—one of the first large-scale installations of the new Turbocharged unit.

TURBO-CHARGED

The KVS *Turbocharged* gas-engine-driven compressor gives Ingersoll-Rand a complete line of heavy-duty 4-cycle units from 110 to 2000-hp. In the 2000-hp KVS engine, dual exhaust-driven turbo-blowers provide intake air pressure for both scavenging and supercharging. Savings in space, weight, fuel and cooling equipment make this an important addition to the I-R line of V-angle, 4-cycle gas engines.

Whatever your pipe-line compressor requirements, Ingersoll-Rand can meet them from a *standard line*—with complete flexibility of compressor cylinder design and arrangement. With each size and type you get the traditional I-R *dependability* that means greater economies on a long-range basis. When planning *your* next installation, be sure to consult your Ingersoll-Rand representative. He can be of great help to you.

very Application



KVS 2000 hp—Turbocharged
as 12 V-angle power cylinders and
ur compressor frames.

6-75

Ingersoll-Rand

11 Broadway, New York 4, N. Y.

In Canada refer to

Canadian Ingersoll-Rand Company, Limited

800 Birks Bldg., Phillips Square Montreal 2, Quebec

CALGARY • KIRKLAND LAKE • NELSON • SHERBROOKE • SYDNEY • TIMMINS
TORONTO • VANCOUVER • WINNIPEG

XUM

PIPE LINE DEVELOPMENTS

Name of Company	Miles	Pipe size, in.	Location	Contractor
Montana-Dakota Utilities Company	56	—	Hettinger and and Stark Counties, North Dakota	Planned
Montana Power	52	16	Canada-Montana border to Cut Bank, Montana.	Planned
Morganfield Natural Gas	31	4-6	Through Sturgis, Providence, Clay, Diamond, Wheatcroft and Sullivan, Kentucky.	Planned
Natural Gas Pipe Line Co. of America	240	24	Carter—Garvin and Stephens counties, Okla., to Hutchinson county, Texas	Planned
Natural Gas Producer, Inc.	100	12	Yenter pool to Denver, Colorado.	Planned
New River Gas	50		Sumners to Monroe counties, West Vir.	Planned
Niagara Gas Transmission, Ltd.	76	20	Lewiston Bridge to Sheridan, Ontario	F. E. Shaw-Conyes Constr.
North Dakota Natural Gas Company	475	6-12	Statewide system in North Dakota.	Planned
Northeastern Gas Transmission	22	8	Upton, Massachusetts to Pawtucket, Rhode Island.	Planned
Northern Indiana Fuel Light	35	8	Edgerton to Alburn, Indiana.	Planned
Northern Natural Gas Company	74	20-24	Paullina, Iowa, to Sioux Falls, South Dakota	R. H. Fulton
Northern Natural Gas Company	93.5	20	Ogden to Waterloo, Iowa	Hallmac Constr.
Northern Natural Gas Company	90	16	Waterloo to Dubuque, Iowa	Engineering-Construction
Northern Natural Gas Company	6	10-16	Cherokee, Iowa, to Sioux Falls, South Dakota	G. G. Griffis
Northern Natural Gas Company	330	2-12	System in South Dakota	Proposed
Northern Natural Gas Company	310	24	Lines in North Dakota	Proposed
Northwest Alabama Gas District	40	9	Southern Natural's line to Haleyville, Alabama.	Certified
Northwest Utilities Ltd.	42	—	Bonnie Glen to Edmonton, Alberta, Canada.	Planned
Ohio Fuel Gas	74	3 to 20	Hocking, Knox, and Ashland counties, Ohio.	Planned
Ohio Fuel Gas	47	20	Benton Township, Hocking County, to Columbus, Ohio.	Planned
Ohio Fuel Gas	69	20-24	Lines to tie in Gulf Interstate line along various points in Ohio.	Proposed
Ohio Fuel Gas	24½	20	Richland and Crawford Counties, Ohio.	Approved
Ohio Fuel Gas	46	—	New Lines in Ohio.	Proposed
Pacific Northwest Pipeline Corp.	1466		Ignacio, Colorado, to Bellingham, Washington.	Approved
Pacific Northwest Pipeline Corp.	380		Laterals and spurs off main line to Pocatello, Idaho to Yakima, Washington.	Proposed
Panhandle Eastern Pipe Line Co.	125	—	Tuscola, Ill. to Mich.-Wis. Pipe Line connection.	Planned
Panhandle Eastern Pipe Line Company	295	—	Loops on existing system	Proposed
Panhandle Eastern Pipe Line Company	97	—	lateral lines	Proposed
Panhandle Eastern Pipe Line Company	178	—	gathering lines in Hugoton field and Andarko basin. (includes 8 field compressor stations).	Proposed
Pine Tree Natural Gas Co.	204	—	Boston to Bangor, Maine.	Planned
Rockland Light & Power Company	22	8	Orangetown to Tompkins Cover, New York.	Proposed
Shenandoah Gas Company	39	3-4-8	Middleton Virginia, to Martinsburg, West Vir.	Proposed
South Georgia Natural Gas Company	368	2-12	Phoenix, Alabama to Tallahassee, Florida.	Approved
Southern Natural Gas Co.	110	18	Loops on southern line.	Williams Bros.
Southwest Gas Corporation, Limited	26	—	From P.G. & E. line to Victorville, California.	Proposed
ennessee Gas Transmission	243	24	Hebron, Pennsylvania to Greenwich, Connecticut.	Planned
Tennessee Gas Transmission	571	30	Kinder, Louisiana to Portland, Tennessee.	Underway
Tennessee Gas Transmission	67	30	Loops in Texas and Louisiana.	Approved
Tennessee Gas Transmission	63	26	Loops in Ohio and Pennsylvania.	Underway
Tennessee Gas Transmission	58	20	Louisiana Gulf Coast to near Kinder, Louisiana.	Approved
Tennessee Gas Transmission	100		Laterals in Texas.	
Tennessee Gas Transmission	45	20	Buffalo, New York to the U. S.-Canadian border, Hamburg station near St. Catherines.	Approved
Texas Eastern Transmission	58	16-20	Joaquin to Longview, Texas.	Proposed
Texas Eastern Penn-Jersey Transmission Corporation	265	24	Oakford storage field to Lambertville, New Jersey.	Underway
Texas Gas Transmission Corporation	48	26	Loops on Memphis-Slaughter line.	Planned
Texas Gas Transmission Corporation	24	16	South Louisiana gas fields.	Approved
Transcontinental Gas Pipe Line Corp.	421	30-36	Loops on Texas-New York main line.	Planned
Transcontinental Gas Pipe Line Corp.	57	—	Louisiana, Mississippi, and Alabama.	Associated Contractors
Transcontinental Gas Pipe Line Corporation	25	12	Cameron and Calcasieu Parishes, Louisiana	Proposed
Trans-Canada Pipe Lines, Ltd.	2247	14-36	Alberta area to Toronto, Montreal	Engineering Underway
Union Gas Company of Canada	180	—	Dawn Storage field to Hamilton	Proposed
United Fuel Gas	50	20-24	Wood County to Hanham, West Virginia.	Fulghum
United Fuel Gas	32	24	Near Ripley, West Virginia to Lanham station. Putman County, West Va.	Proposed
United Fuel Gas	57	30	Lanham in Kanawha County, West Va., to Gulf Interstate line.	H. C. Price Co.
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania.	Planned
Utah Natural Gas Company	40	16	Orem to Salt Lake City, Utah.	Planned
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Va.	Proposed
Warren Petroleum	54	4-30	Lea County, New Mexico.	Planned
Wyoming Gas Products Corp.	—	—	Gas gathering system in Weston County, Wyo.	Planned

FOREIGN CRUDE LINES

Assam Oil Company	20	8	Brahmaputra Valley field to Digboi, Northeast India	Planned
Arabian American Oil Company	18	22-20	Qatif to Ras Tanura No. 3	Completion date 1-55.
Atlas Corporation	400	16	Fields in Neuquen territory to Bahia Blanda, Argentina	Proposed
Bombay Port Trust	50	8 to 24	Bombay, India, to serve Standard Vacuum Oil Co.	Merritt, Chapman and Scott Corp.
Creole Petroleum Corporation	21	34	Lagunillas to La Salina (State of Zulia, Venezuela)	Williams Brothers Overseas Company
Direccion General de Yacimientos Petroliferos Fiscales	409		Plaza Huincul to Bahia Blanca, Argentina.	Under way
Egyptian Government	84	—	Suez-Cairo crude line.	Underway
Iraq Petroleum Company	—	20	Line diversion from Kirkuk-Haifa line to Lebanese coast terminal.	Planned
Petroelos Mexicanos	145	12	18 de Marzo field via Raynosa to Monterrey.	Considered
Petroleos Mexicanos	72	12	Poza Rica to Atzacapotzalco, Mexico.	Proposed
Petroleos Mexicanos	125	10	Jose Colomo to El Plan, Mexico.	Under way
Saskatoon Pipe Line, Limited	56	6	Milden to Saskatoon, Saskathewan, Canada.	Planned
Texas Petroleum Co.	60	4-6	Pta. Nio to La Dorada.	Under way
Texas Company	120	12	Porte Nino to Galan, Colombia, South America	Panama-Williams & Foster Wheeler
Yacimientos Petroliferos Fiscales Bolivianos	170	4	Bermejo to Tupiza, Bolivia.	Planned

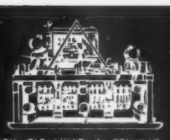
FOREIGN PRODUCT LINES

Anglo-Iranian Oil Company, Ltd.	18½	6 & 16	Little Aden to Aden.	Bechtel Corporation
Anglo-Iranian Oil Company, Ltd.	15	12	Kwinana to Fremantle.	M. W. Kellogg Company. Completion date Feb., 1955.
Anglo-Iranian Oil Company, Ltd.	17	6	Kwinana to Fremantle.	M. W. Kellogg Company Completion date Feb., 1955.
Empresa Nacional del Petroleo	80	6⅝	Concon to Santiago, Chile.	Planned
Empresa de Petroleos	60	8	Contimplaca to Berrancabeneja, Colombia, South America	Anderson Bros. de Colombia
Governments of Southern Rhodesia and Portuguese E. Africa	200		Beria, Portuguese Mozamque to Umtalia, Southern Rhodesia.	Considered
North Atlantic Treaty Organization (NATO)	1920	4-10	To serve military bases in Western Europe.	Foster Wheeler
Petroleos Mexicanos	124	6	Lagos to Guadalajara, Mex.	Planned
Petroleos Mexicanos	54	6	Lagos to Aguascalientes, Mexico.	Planned
Petroleos Mexicanos	82	8	Salamanca to Lagos, Mex.	Planned

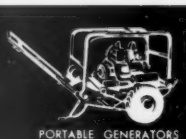
FOREIGN GAS LINES

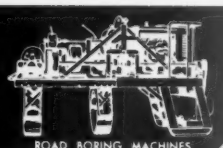
Azienda Generale Italiana Petroli	90	12	Cortemaggiore to Bologna, Italy.	SNAM crews
Azienda Generale Italiana Petroli	120	16	Cremona Porto Mar to Ghera, Italy.	Montubi, Contractor
Azienda Generale Italiana Petroli	40	12	Rapalta-Bergamo, Italy.	
Dirrecion General del Gas del Estado	310	8	Plaza Huincul to Neuquen, Argentina.	
Empresa Macional del Petroleo	80	10	Concon to Santiago, Chile.	Planned
Petroleos Mexicanos	205	16	Monterrey to Torreon, Mex.	Under way
Petroleos Mexicanos	440	20	Brazil to Tampico to Poza Rica, Mexico.	Planned
Sui Gas Transmission Company, Karachi, Pakistan	350	16	Sui gas field to Karachi, Pakistan.	River Construction Company

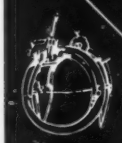
PIPELINE KETTLES


STATIONARY CLEANING & PRIMING MACHINES

YARD PIPE RECONDITIONING EQUIPMENT


PORTABLE GENERATORS


ROAD BORING MACHINES


CUTTING & BEVELING MACHINES

CLEANING & PRIMING MACHINES

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Model M —for 3" to 14" pipe.
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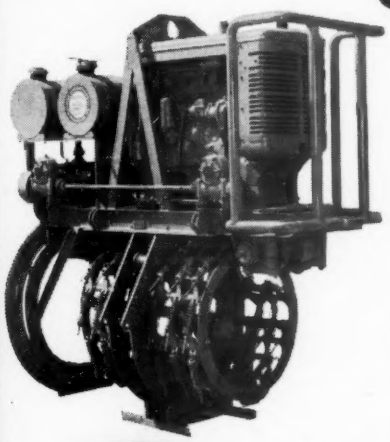
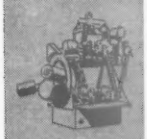


The most rugged and dependable cleaning and priming machine on the line . . . equipped with dual multi-speed transmissions providing greater flexibility of control. Interchangeable cleaning and priming assemblies permit each model to process a wide range of pipe sizes.

PIPELINE CRADLES

INTERNAL LINE-UP CLAMPS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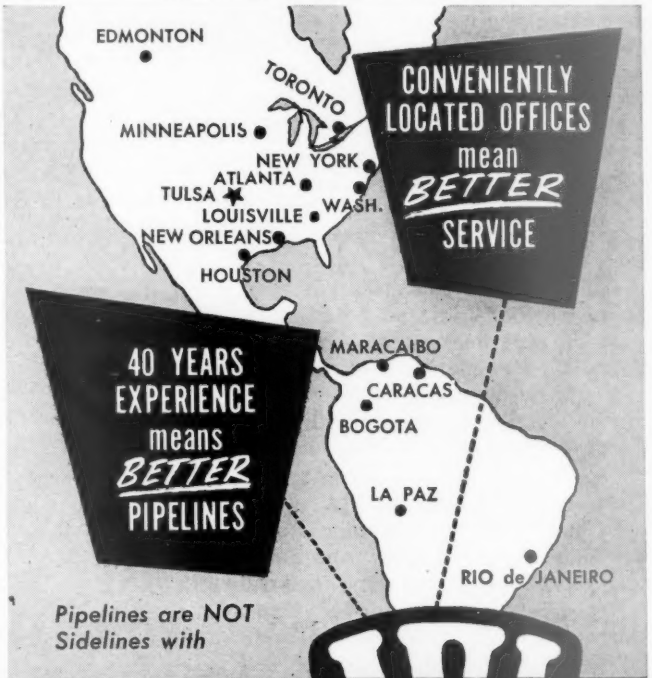
*City*_____ *State*_____



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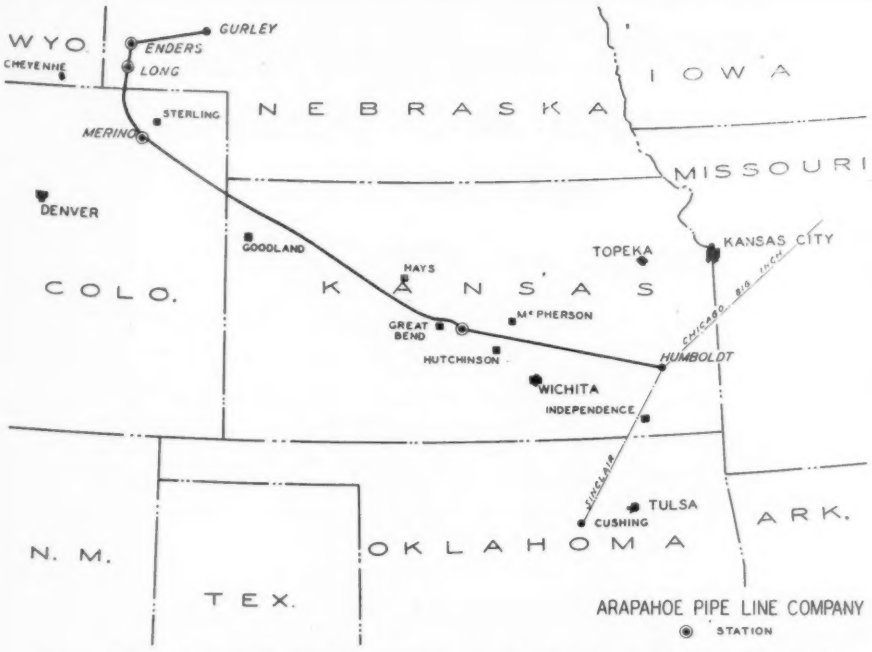
Pipe Line Projects



Route of new Arapahoe Pipe Line Company, joint venture of Sinclair and Pure.

Arapahoe Pipe Line Awards Contracts

Arapahoe Pipe Line Company has awarded contracts for the construction of the company's 18 and 20-in. pipe line between Merino, Colorado and Humbolt, Kansas.

Construction will start immediately. Pipe is in production and en route and delivery will be completed by September 30, 1954. Construction offices for this project have been established in the Airport Building at Hutchinson, Kansas.

Capital stock of Arapahoe Pipe Line Company is owned by the Pure Oil Company and Sinclair Pipe Line Company. Sinclair will supervise the construction of the line and upon completion, it will operate the system as agent for Arapahoe. The Arapahoe line is scheduled for operation early in 1955.

Successful bidders for this project are as follows:

Section 1—149 miles of 18-in.—Merino, Colorado to Colby, Kansas, R. H. Fulton and Company, Lubbock, Texas.

Section 2—162 miles of 18-in.—Colby, Kansas to Schurr Station, Kansas, R. H. Fulton and Company, Lubbock, Texas.

Section 3—84 miles of 20-in.—Schurr Station to Burns, Kansas, R. H. Fulton and Company, Lubbock, Texas.

Section 4—86 miles of 20-in.—Burns to Humboldt, Kansas, Panama-Williams Company, Houston, Texas.

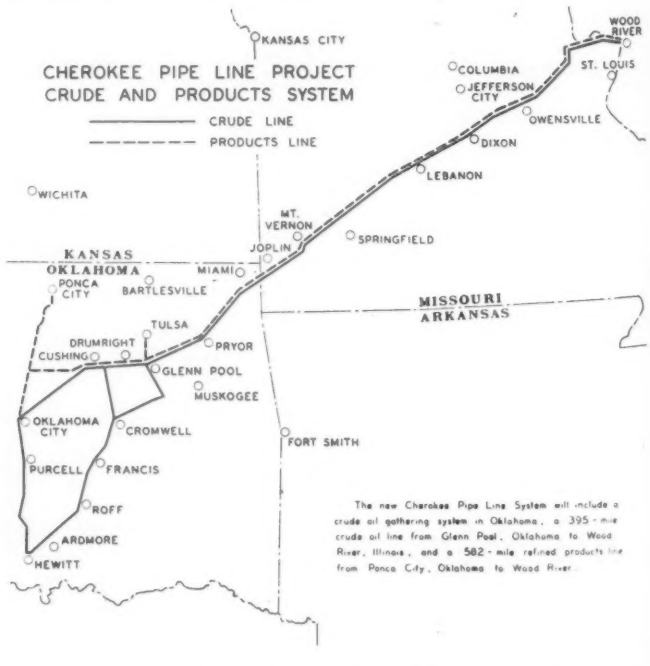
Cherokee Pipe Line Plans Crude, Products System

Purchase of a 1050-mile crude oil pipe line gathering and trunk system in Oklahoma from Interstate Oil Pipe Line Company, and 2 crude oil lines extending 395 miles from Glenn Pool, Oklahoma, to Wood River, Illinois, from Ajax Pipe Line Company, has been made by Cherokee Pipe Line Company, of which Continental Oil Company and Cities Service Company each own 50 per cent.

Plans call for conversion of parts of the 2 systems into an 8 and 10-in. products pipe line system. Also to be purchased by Cherokee and converted to products transportation is a 32-mile oil line extending from Guthrie to Cushing, Oklahoma, owned by Cities Service and 82 miles of oil line from Tonkawa to Oklahoma City, owned by Conoco. The products line system will then extend 582 miles from Ponca City to the Oklahoma City area and to Wood River, just north of St. Louis, and will have an initial daily throughput of 22,000 bbl. Both Conoco and Cities Service have large refineries at Ponca City. The products line will be operated by Continental Pipe Line Company.

The Oklahoma crude oil gathering and trunk system purchased from Interstate consists of approximately 1050 miles of from 2 to 12-in. pipe lines in the south central part of the state. Forming a loop from Drumright to Hewitt to Oklahoma City and back to Drumright, the system connects with the Glenn Pool to Wood River crude lines and provides an outlet for a substantial amount of crude production in the area. Cities Service Pipe Line Company will operate the crude oil system for Cherokee.

Cherokee assumed the lines September 1. Work on conversion of the crude oil lines to products service will start early this fall.

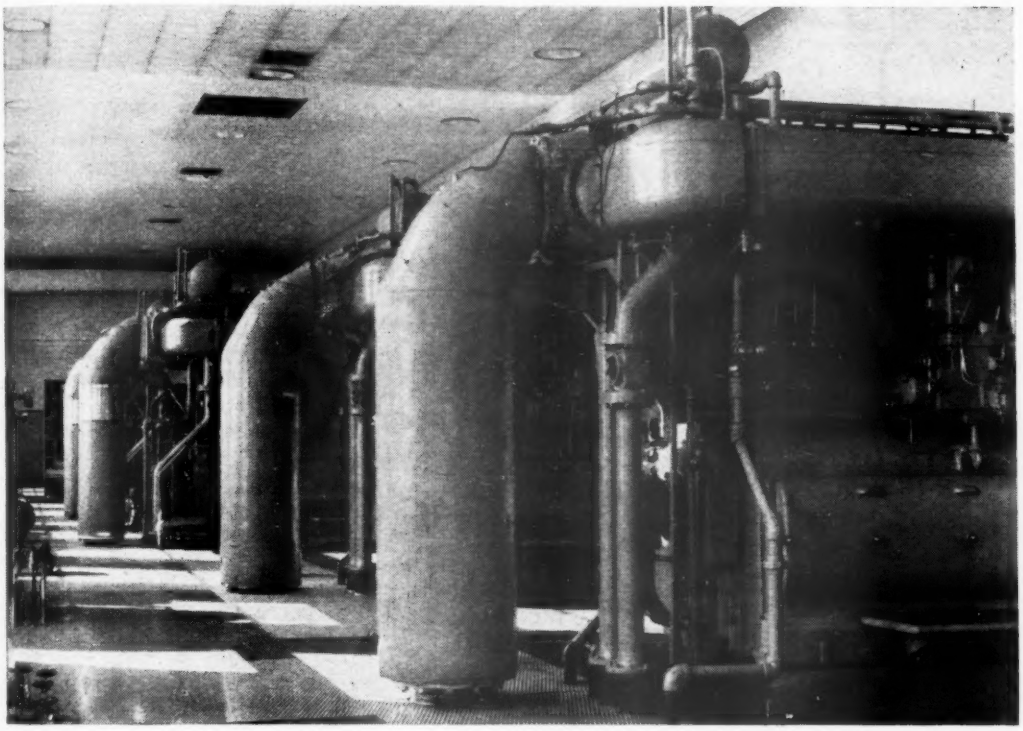


Map shows relationship of the crude and products systems of Cherokee Pipe Line Company.

Another Pipe Line Company Reports

2 to 3 times more horsepower hours

. . . after installing Koppers Conformable Oil Rings



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Koppers Conformable Ring maintains constant unit pressure for positive oil control. Conforms readily to meet cylinder distortion because flexible cast iron member is pressed outward by abutment type spring which exerts uniform radial pressure around entire circumference.

*Van der Horst Process

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As a result, this pipe line company has adopted Koppers Piston Rings as standard equipment on all their 12½" x 13" turbo-charged engines.

Does this suggest possible savings in your operation? Less oil consumption? Less down time, lower labor costs? Then investigate Koppers Porous Chrome* and Conformable Oil Rings. And install them next time you have a piston ring replacement job.

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Dotted line shows route of new Western Pipe Line, subsidiary of Service Pipe Line.

Western Pipe Line Formed To Build Rockies Outlet

Formation of Western Pipe Line Company to build and operate a new common carrier crude pipe line from the Rocky Mountain area to the midwest has been announced by Service Pipe Line Company.

The new company, a subsidiary of Service Pipe Line Company, plans to have its line in operation by the end of 1954. Service is a subsidiary of Standard Oil Company (Indiana) and operates the largest pipe line system.

The new 603-mile line will run from Ft. Laramie, Wyoming to Freeman, Missouri near Kansas City. At Freeman the oil will be delivered by Western into Service Pipe Line's big-inch system for transportation to refineries in the Kansas City, Wood River, and Chicago areas, and other lines.

The new line will be 20-in. from Ft. Laramine, Wyoming to Sterling, Colorado; 22-in. from Sterling to Natoma, Kansas, and 24-in. from Natoma to Freeman, Missouri. Initial capacity of the line into Freeman will be 160,000 bbl a day. The line is being designed to handle over 200,000 bbl a day with additional pump stations. Service Pipe Line Company's west Kansas system will be connected to Western near Natoma, Kansas.

Until completion of the Western project, Service's present Ft. Laramie to Freeman line will remain in operation. Service's Wyoming system west of Ft. Laramie will continue to operate as at present. It serves producing fields in the Wind River, Big Horn, and Powder River basins, and refineries in the Rocky Mountain area.

Service pioneered pipelining from the Rocky Mountain area in 1923 with a 700-mile 10- and 12-in. line from Wyoming to Freeman, Missouri. Immediately after World War II there was need for increased capacity out of the Rocky Mountain area to keep pace with new oil discoveries. Despite the serious pipe shortage at the time, Service (then Stanolind) increased the capacity of its line by laying 16-in. to the extent pipe was available, replacing the original 10-in. and reactivating several pump stations.

New line will afford the advantage of a modern big-inch lower-operating-cost system with built-in capacity for the future in lieu of Service's present Rocky Mountain system.

New Firm Formed to Handle Trans-Canada Construction

A newly-formed company, Bechtel-Mannix-Hester, will be in charge of design, engineering, and construction of Trans-Canada Pipe Lines, Ltd.'s 2200-mile natural gas pipe line.

The new company represents the pooling of resources and experience of the leading pipe line building organizations — Canadian Bechtel Limited, Toronto, Canada, Mannix Limited, Calgary, Canada, and Oklahoma Contracting Company, Dallas, Texas.

Completion of the project is scheduled for the end of 1956. The company plans to sell natural gas in Saskatchewan, as far east as Winnipeg, and to the Minnesota area next fall, and service from the line will be available in Toronto and Montreal a year later.

Trans-Canada is now completing purchase contracts with the owners of the gas in Western Canada and sales agreements with the public and private utilities which will distribute the fuel in the municipalities along the route of the line. Financing of the $300,000,000 project, which will follow the negotiation of purchase and sales contracts, will be undertaken this fall.

While the actual laying of pipe on the line will not get started until next spring, surveying, right-of-way negotiations and clearance will be started immediately.

Ohio Fuel Plans Short Line, Compressor Additions

Ohio Fuel Gas Company, Columbus, Ohio, has requested FPC authorization for 46 miles of pipe line and 3000 additional compressor horsepower on its main system in Ohio to enable it to receive additional natural gas from its affiliate, United Fuel Gas Company. Both companies are Columbia Gas System subsidiaries.

Ohio Fuel proposes to build 17.3 miles of 20-in. and 29 miles of 24-in. paralleling parts of its existing line in Jackson, Vinton, Hocking, and Fairfield counties, Ohio. Company also plans to install two 1500-hp compressor units at its Crawford compressor station in Fairfield County.

Wyoming Line Planned As Platte Connection

Application has been filed with the Wyoming Public Service Commission for authority to build a 58-mile, 10-in. crude line from Lance Creek to Fort Laramie, Wyoming, by the Cheyenne Valley Pipe Line Company. The $1,800,000 line would transport crude from Plains Pipe Line's Lance Creek Station to a connection with Platte Pipe Line at Fort Laramie.

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South Saskatchewan Line Completion Hurried

Fulton Banister, Ltd., has put 2 spreads to work on its contract for 155 miles of 16-in. crude pipe line for South Saskatchewan Pipe Line Company, linking the Fosterton-Cantuar-Success medium gravity oil fields of southwestern Saskatchewan with Moose Jaw station on the Interprovincial pipe line. Destination of the crude is St. Paul, Minnesota, via the Minnesota Pipe Line Company crude line, which will take off from Clearbrook station on Interprovincial's subsidiary Lakehead pipe line.

The new pipe line system will provide the first outlet for Saskatchewan medium crude to outside markets, with an expected initial throughput of 15,000 to 20,000 bbl per day. Capacity of the line, without intermediate pumping stations, is to be 25,000 bbl daily or about 2½ times the current production of crude for the entire province. Projected completion date is early in October, before the ground freezes up. It will go into operation about the middle of next summer; in preparation for the opening of the refinery in St. Paul which is scheduled for completion in July or August, 1955.

Texas-Florida Gas Line Proposed by Houston Firm

Authority will be sought soon from the FPC to construct a 1000-mile, 34-in. natural gas line from Texas and Louisiana producing areas to markets in Florida, according to J. O. Mack, president of Houston Texas Gas and Oil Company, firm planning the line.

Engineering work on the line has been completed and estimated cost for the system, including laterals for gathering and distribution, is $148,000,000. Current plans call for construction of the line prior to beginning work on two 30-in. lines the company has previously proposed, one to the Chicago-Detroit area, and another to the New York area.

Section of Badger Line Contracted, Underway

Construction has begun on the East Chicago-to-Harlem Avenue sector of the 195-mile Badger products pipe line to Madison, Wisconsin, by Morrison Construction Company, Hammond, Indiana. The Morrison contract also includes construction of a pump station at East Chicago.

The East Chicago-to-Harlem Avenue sector extends from the Cities Service refinery at East Chicago westward to a point near Lemont and then up the sanitary canal to Harlem Avenue. At this point, the line will serve several oil products terminals.

Approval Sought on 61 Miles by Manufacturers

Manufacturers Light and Heat Company, Pittsburgh, Pennsylvania, has applied to the Federal Power Commission for authority to construct approximately 61 miles of transmission line and 1760-hp in compressor capacity on its system in Ohio, Pennsylvania, and West Virginia.

Proposed new facilities would be located in Columbiana, Belmont, and Monroe counties, Ohio; Ohio County, West Virginia, and Beaver, Washington, Allegheny, and Westmoreland counties, Pennsylvania.

Kansas-Nebraska to Build 221 Miles of Gas Line

Kansas-Nebraska Natural Gas Company, Inc., Phillipsburg, Kansas, will construct a total of about 221 miles of pipe line and 2700 hp in compressor capacity on its natural gas transmission system in Nebraska.

Facilities to be constructed by Kansas-Nebraska have a total estimated cost of $4,096,890. The new pipe will range in diameter from 6 to 12-in. Of the proposed additional compressor capacity, 1500-hp will be installed at a new station and the remaining 1200-hp at an existing station.

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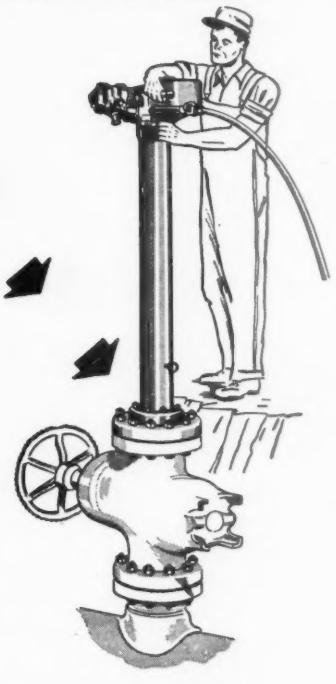

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Projects

Price Safety Record Given National Recognition

National recognition of the safety record established by the H. C. Price Company, pipe line construction firm, has been given by the receipt of three Certificates of Honor from the Joseph A. Holmes Safety Association.

The Holmes Safety Association operates under the auspices of the U. S. Bureau of Mines in Washington, District of Columbia. Awards were presented to the pipe line construction firm for the overall safety record established during 1953 under the supervision of safety director Bennie G. Pierce, and also to 2 individual members of the firm. Individuals who received the important safety awards are Forrest Loinette and W. H. Olrich.

Trans-Canada Line to Be 30-in. Board Decides

The Trans-Canada natural gas pipe line from southeastern Alberta to Winnipeg, Minneapolis and Toronto-Montreal, for which the Canadian Board of Transport Commissioners has granted a permit conditional on the company (Trans-Canada Pipe Lines Limited) securing the necessary financing by the end of 1954, will be a 30-in. line, according to the Board's official announcement. The company proposed this size as a compromise to permit the line to be built in stages, although some engineering opinion within the organizing group was to the effect that a 36-in. line would be more economical in operation for the anticipated load factor after the initial build-up period.

Company is presently assembling management personnel and conducting preliminary route surveys, as well as preparing advanced engineering studies, with right-of-way clearing scheduled to begin early in 1955.

Houston-Sour Lake Line Begins Operation

Cities Service's new 60-mile pipe line from Houston to Sour Lake, Texas, has been put into operation with initial delivery of 42,700 bbl of oil. Maximum capacity of the 12-in. line is 70,000 bbl daily. In connection with construction of the Houston pump station, six 120,000-bbl tanks have been erected to receive crude from connecting carriers. The extension enables Cities Service to take oil from its affiliated Texas-New Mexico Pipe Line system and other pipe lines at Houston, and transport it to Sour Lake where it enters the company's 20-in. line to Lake Charles, Louisiana.

South Georgia Plans 368-Mile System in Georgia, Florida

South Georgia Natural Gas Company, of Birmingham, Alabama, has received tentative FPC approval to construct and operate a 368.3-mile natural gas transmission system to serve new market areas in Georgia and Florida.

South Georgia's transmission line will begin at a point of connection with the Southern Natural Gas Company pipe line system in Lee County, Alabama, and extend southeast to near Albany, Georgia.

Northern Natural Seeks South Dakota Line Okay

Northern Natural Gas Company, of Omaha, Nebraska, has applied to FPC for authority to construct 330 miles of pipe line to supply natural gas service to 20 communities in South Dakota.

Northern proposes to extend its main line facilities from a point near Sioux Falls, South Dakota, about 165 miles in a northwesterly direction to Aberdeen, South Dakota. The company also would build about 164½ miles of branch lines, and town border stations to make gas available to the 20 towns. Total estimated cost of the project is $6,661,100.

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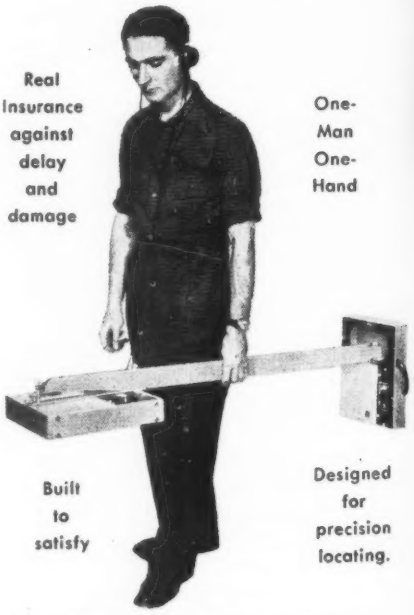

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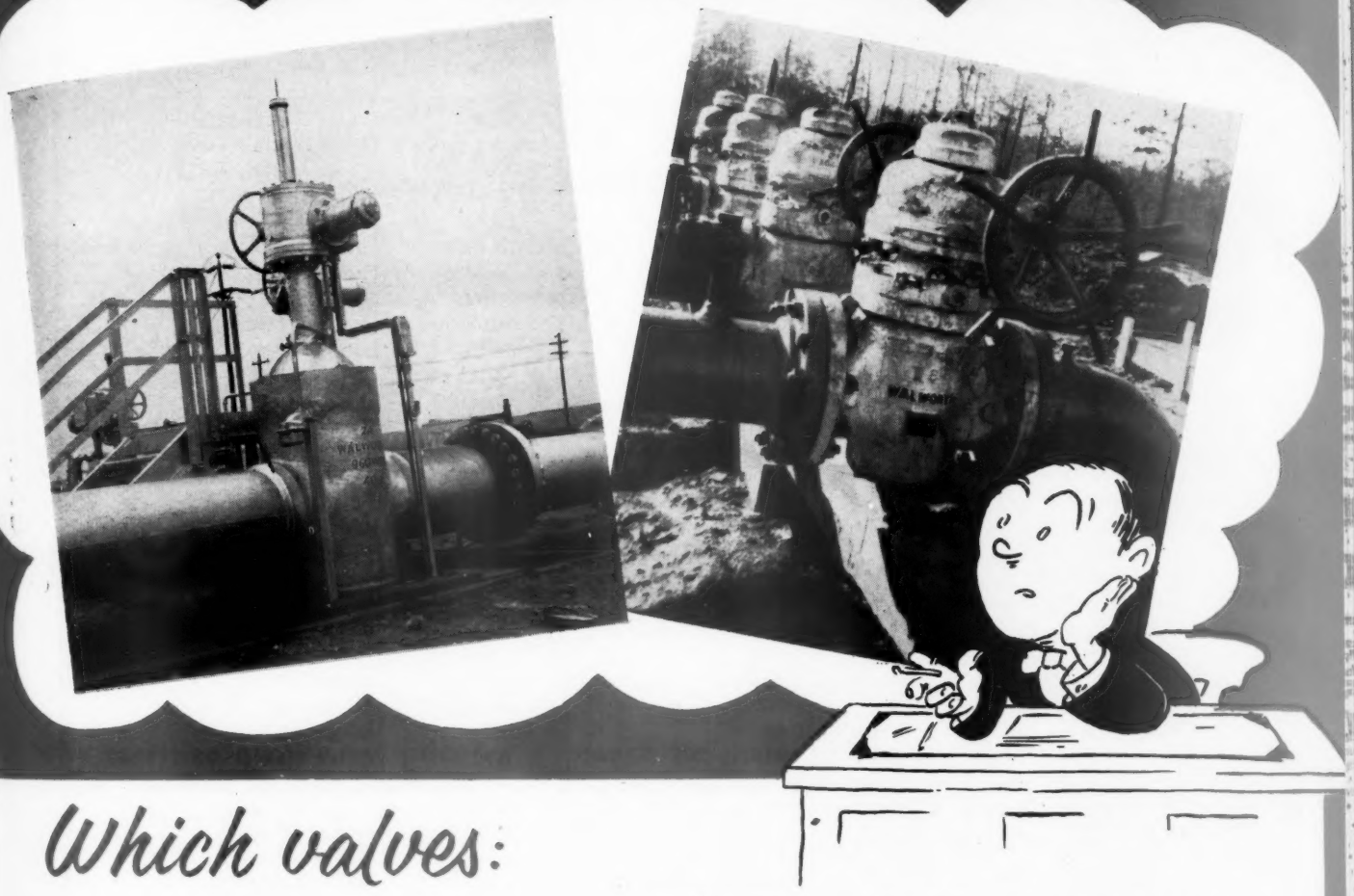

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meters	3.281	feet	0.3048	meters
kilometers	0.6214	miles	1.6093	kilometers
square centimeters	0.1550	square inches	6.4516	square centimeters
square meters	2.471×10^{-4}	acres	4046.9	square meters
square meters	10.76	square feet	0.092937	square meters
square meters	1.196	square yards	0.83612	square meters
square kilometers	0.3861	square miles	2.590	square kilometers
square kilometers	247.1	acres	4.047×10^{-3}	square kilometers
ares	0.02471	acres	40.47	ares
hectares	2.471	acres	0.4047	hectares
cubic centimeters	6.102×10^{-2}	cubic inches	16.388	cubic centimeters
cubic centimeters	2.642×10^{-4}	gallons U. S.	3785.3	cubic centimeters
cubic centimeters	2.201×10^{-4}	gallons Imperial	4543.6	cubic centimeters
liters	61.02	cubic inches	1.6388×10^{-2}	liters
liters	0.03531	cubic feet	28.32	liters
liters	0.2642	gallons U. S.	3.7853	liters
liters	0.2201	gallons Imperial	4.5436	liters
liters	6.2905×10^{-3}	barrels (42 gal.)	158.97	liters
cubic meters	35.31	cubic feet	0.02832	cubic meters
cubic meters	1.308	cubic yards	0.7645	cubic meters
cubic meters	264.2	gallons	3.785×10^{-3}	cubic meters
cubic meters	6.2905	barrels (42 gal.)	0.15897	cubic meters
Imperial gallons	0.833	U. S. gallons	1.200	Imperial gallons
atmospheres	14.70	pounds per square inch	0.068027	atmospheres
atmospheres	33.90	feet of water	0.0295	atmospheres
atmospheres	29.92	inches of mercury	0.03342	atmospheres
kilograms per square meter	1.422×10^{-3}	pounds per square inch	703.23	kilograms per square meter
kilograms per square meter	0.2048	pounds per square foot	4.883	kilograms per square meter
kilograms per square meter	9.678×10^{-5}	atmospheres	10,332.7	kilograms per square meter
millimeters mercury	1.9268×10^{-2}	pounds per square inch	51.9	millimeters mercury
grams	2.205×10^{-3}	pounds	453.5	grams
kilograms	2.205	pounds	0.4535	kilograms
kilograms	1.102×10^{-3}	tons	907.4	kilograms
metric tons	1.102	tons	0.9074	metric tons
tons of 12° oil	5.7924	barrels of 12° oil	0.17264	tons of 12° oil
tons of 16° oil	5.9538	barrels of 16° oil	0.16796	tons of 16° oil
tons of 20° oil	6.1151	barrels of 20° oil	0.16353	tons of 20° oil
tons of 24° oil	6.2763	barrels of 24° oil	0.15933	tons of 24° oil
tons of 28° oil	6.4383	barrels of 28° oil	0.15532	tons of 28° oil
tons of 32° oil	6.5998	barrels of 32° oil	0.15152	tons of 32° oil
tons of 36° oil	6.7613	barrels of 36° oil	0.14790	tons of 36° oil
tons of 40° oil	6.9223	barrels of 40° oil	0.14446	tons of 40° oil
tons of 44° oil	7.0842	barrels of 44° oil	0.14116	tons of 44° oil
tons of 48° oil	7.2448	barrels of 48° oil	0.13803	tons of 48° oil
gram-calories	3.968×10^{-3}	British thermal units	252.02	gram-calories
kilogram-calories	3.968	British thermal units	0.252	kilogram-calories
kilogram-calories per minute	0.09351	horsepower	10.694	kilogram-calories per minute
grams per cubic centimeter	62.43	pounds per cubic foot	0.016018	grams per cubic centimeter
kilograms per cubic meter	0.06243	pounds per cubic foot	16.018	kilograms per cubic meter
degrees centigrade + 17.8	1.8	degrees fahrenheit —32	5/9	degrees centigrade

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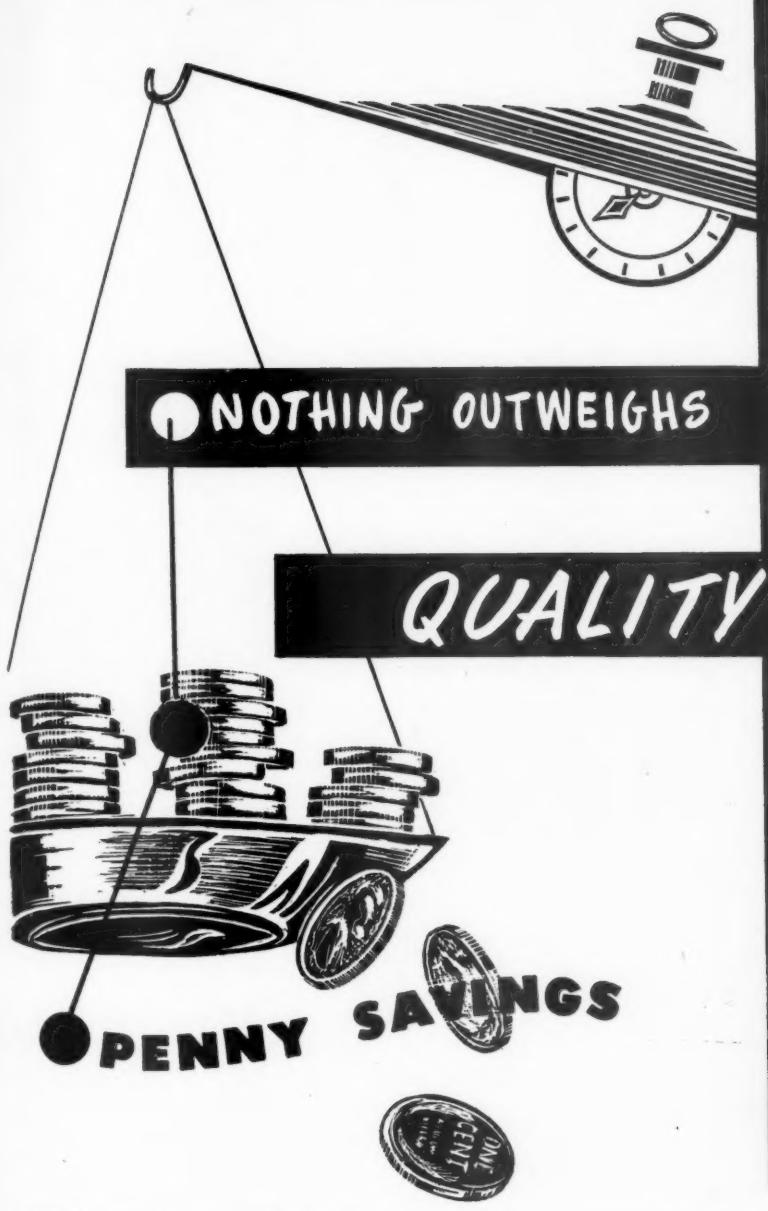

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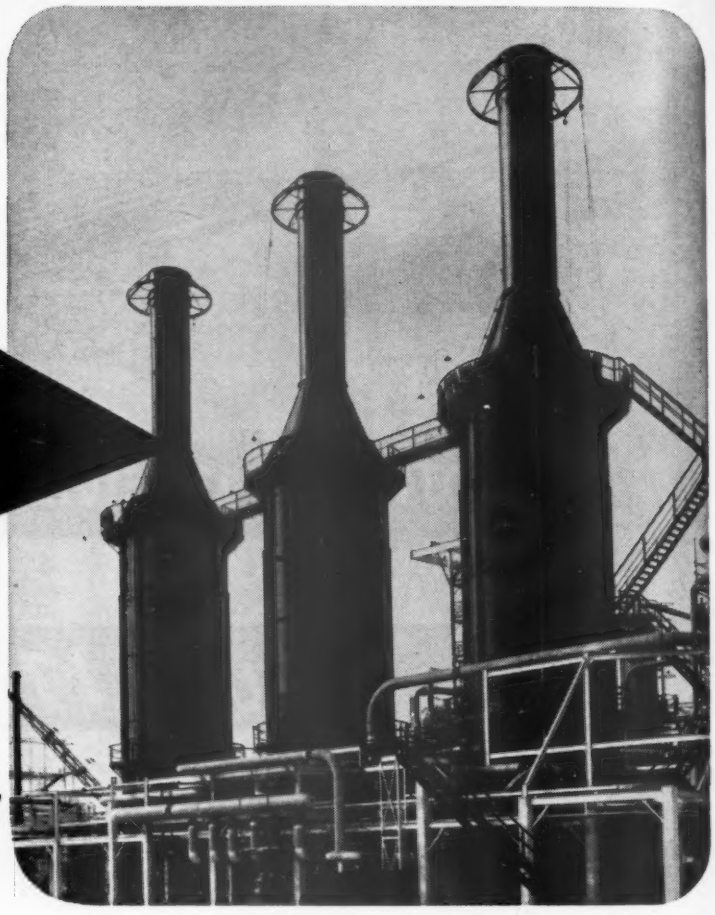

stays bright and glossy; lasts longer at 700° F

THE CIT-CON OIL REFINERY near Lake Charles, Louisiana, is one of the newest and largest fully integrated lubricating oil and paraffin wax plants. A joint enterprise of Cities Service and Continental Oil, the plant is finished in sparkling aluminum and gleaming black. What's unusual is that the black is used to protect the surface areas of such large units as petroleum furnaces and exhaust stacks.

Soon after this modern refinery was completed, it became evident that even the most heat-resistant organic black finishes would not last from one annual unit shutdown to the next. The best of them developed rust stains in a few months.

Then in July 1952, when the steam boiler was down, the three 100 foot stacks in the unit were wire-brushed and a single coat of a silicone resin based black finish* was applied. The coating was allowed to air dry and cure in service. Later the petrochem heater stacks and all other stacks in the plant were refinished in the same manner.

Today, two years later, the black finish looks as bright and glossy as ever, despite surface temperatures ranging from 350° to 700° F. Unit shutdown time has come and gone for most of the stacks with no refinishing necessary. The silicone paint has already paid for itself in reduced refinishing costs.

That's the kind of performance you can expect from protective coatings formulated with Dow Corning silicone resins. Wherever high temperatures, corrosive atmospheres or both combine to limit the life of organic coatings, silicone based finishes cut maintenance costs, reduce down-time and improve plant appearance. For more information and list of suppliers, mail this coupon today.

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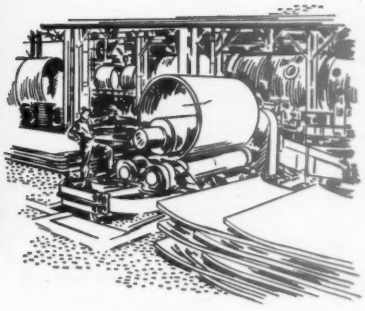

It is the attitude of the workman that assures excellence. When he will give only his best, the product is the best.

This attitude has prevailed in Wyatt's Shops since the first job was completed in that little building on Coombs Street in Dallas, back in 1913.

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CALCULATION OF SUCKER ROD LOAD, STRETCH, AND PLUNGER TRAVEL

TABLE A
Impulse factor K

Strokes per minute s. p. m.	Length of stroke, in.							
	24	30	34	37½	44	54	64	74
10	1.045	1.056	1.063	1.069	1.082	1.100	1.118	1.137
12	1.053	1.067	1.076	1.083	1.098	1.120	1.142	1.165
14	1.062	1.078	1.088	1.097	1.114	1.140	1.166	1.192
16	1.071	1.089	1.101	1.111	1.130	1.160	1.190	1.220
18	1.080	1.100	1.113	1.125	1.147	1.180	1.213	1.247
20	1.089	1.111	1.126	1.139	1.163	1.200	1.237	1.275
22	1.098	1.122	1.138	1.153	1.179	1.220	1.260	1.302
24	1.107	1.133	1.151	1.167	1.196	1.240	1.284	1.330
26	1.116	1.144	1.164	1.180	1.212	1.260	1.308	1.357
28	1.124	1.156	1.176	1.194	1.228	1.280	1.331	1.384
30	1.133	1.167	1.189	1.209	1.245	1.300	1.355	1.411
32	1.142	1.178	1.202	1.222	1.260	1.320	1.380	1.439

$$K = 1 + \frac{s \times s.p.m.}{5400}$$

s = length of stroke, in.
s.p.m. = strokes per minute

TABLE B
Size, weight, and cross-sectional area of sucker rods, pull rods and polished-rod pins

Rod size—diameter, in.	⅝	¾	⅞	1
Sucker Rods				
Cross-sectional area sq. in.	0.307	0.442	0.601	0.785
Weight of rods (box and pin), lb. per ft.	1.110	1.600	.....	.....
Weight of rods (pin and pin with coupling), lb. per ft.	1.120	1.620	2.250	2.880
Pull rods				
Cross-sectional area, sq. in.	0.307	0.442	0.601	0.785
Weight of rods and clamps. lb. per ft.	1.120	1.600	2.250	2.920
Polished rods				
Pin size—O. D., in.	1⅛	1⅛	1⅛	1⅜
10 thread pin—root diam., in.	0.804	0.929	1.054	1.240
10 thread pin—root area, sq. in.	0.508	0.678	0.873	1.208

TABLE C
Combined sucker-rod and fluid weights

Diameter pump plunger. in.	W = combined dead weight of rods and fluid in lb. per ft.*			
	⅝-in. rods, lb. per ft.	¾-in. rods, lb. per ft.	⅞-in. rods, lb. per ft.	1-in. rods lb. per ft.
1	1.46	1.94	2.59	....
1¼	1.50	1.98	2.63	3.26
1½	1.65	2.13	2.78	3.41
1¾	1.89	2.37	3.02	3.65
1¾	2.16	2.64	3.29	3.92
1¹⅞	2.40	2.88	3.53	4.16
2	2.48	2.96	3.61	4.24
2¼	2.84	3.32	3.97	4.60
2½	3.25	3.73	4.38	5.01
2¾	3.69	4.17	4.82	5.45
3¾	5.90	6.38	7.03	7.66

*Based on pin-and-pin rod weights. Specific gravity of fluid = 1.000 (water at 39.1° F.) Weight of fluid per cu. in. = 0.0361 lb.

Example:

What is the peak polished rod load, total stretch of the rod string, and the actual pump plunger travel in a well that has 3600 ft. of ⅝-in. pin and pin sucker rods, a pump bore of 1½ in., 2-in. tubing, 14 strokes per min., and a polished rod stroke of 54 in.?

Calculation of Peak Polished Rod Load

Formula: [1] $P = W \times L \times K$,

Where:

P = peak polished rod load neglecting buoyancy,
W = dead weight of rods plus the weight of the fluid in lb. per ft.,
L = length of sucker-rod string, and
K = impulse factor.

In Table A, the impulse factor K for 14 s.p.m., 54-in. stroke is 1.140. In Table C, W, the dead weight of the rods plus the weight of the fluid for ⅝-in. rods and a 1½-in. pump plunger is 1.89. Length of the string is 3600 ft.

Substituting:

$P = 1.140 \times 1.89 \times 3600 = 7756.56$ lb. peak polished rod load.

Note: These calculations are intended only for use in the preliminary design of a rod string. No consideration is given harmonic motion of rod string or friction. For more accurate results a stress dynamometer or similar stress equipment should be employed.

Calculation of Total Stretch of the String

Formula: $S = \frac{(P - WsK)L}{Em \times A}$

Where:

S = total stretch in in.,
P = peak polished rod load (7756.56 lb.),
Ws = weight of rod string in lb.,
L = length of the string in in.,
Em = modulus of elasticity, 29,000,000,
A = cross-sectional area of rods, sq. in., and
K = impulse factor (1.140).

In substituting in the formula P is 7756.56 lb. as calculated previously, Ws is the length of the rods (3600 ft.), multiplied by the weight in lb. per ft., taken from Table B for ⅝-in. pin and pin rods (1.120) times the impulse factor (1.140) from Table A is equal to 4596.48. L is the 3600 ft. converted to in., 43,200. Em is 29,000,000 and A, the cross-sectional area of the ⅝-in. rod is 0.307 sq. in. taken from Table B.

$$S = \frac{(7756.56 - 4596.48)\ 43{,}200}{29{,}000{,}000 \times 0.307} = \frac{136{,}515{,}456}{8{,}903{,}000}$$

$= 15.33$ in. total stretch of the rods.

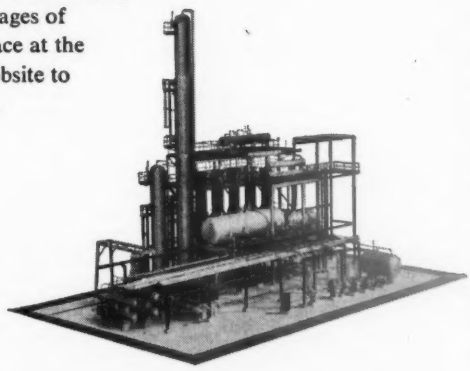
Calculation of Pump Plunger Travel

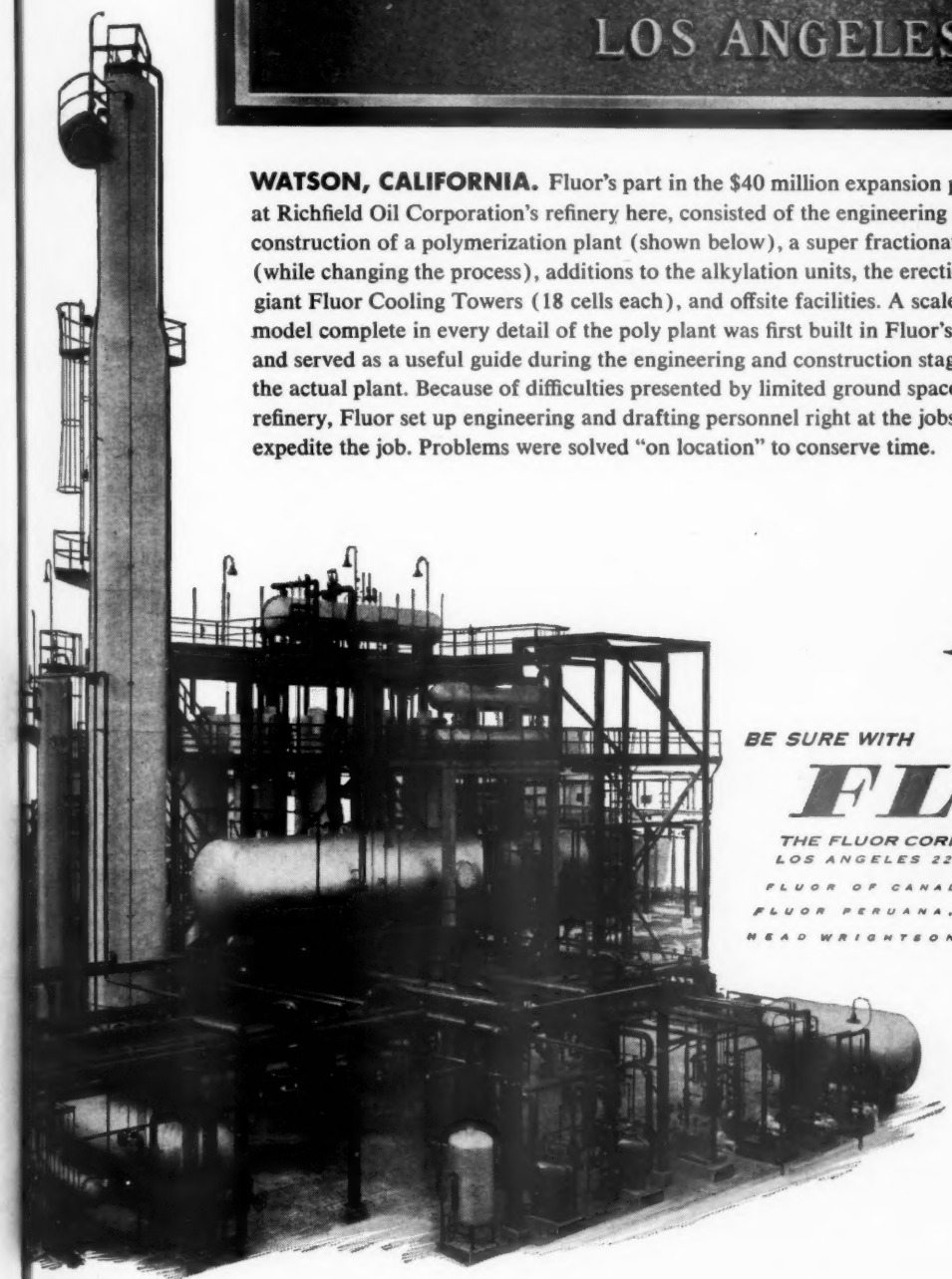
The actual pump plunger travel is found by subtracting the stretch of the rods from the 54-in. stroke. 54 — 15.33 = 38.67 in.

[1] This formula is derived from A.P.I. Standards No. 11 E, Third Edition—adopted May, 1939.

THIS PLANT DESIGNED AND CONSTRUCTED BY THE FLUOR CORPORATION LTD. LOS ANGELES

WATSON, CALIFORNIA. Fluor's part in the $40 million expansion program at Richfield Oil Corporation's refinery here, consisted of the engineering and construction of a polymerization plant (shown below), a super fractionation system (while changing the process), additions to the alkylation units, the erection of two giant Fluor Cooling Towers (18 cells each), and offsite facilities. A scale model complete in every detail of the poly plant was first built in Fluor's model shop and served as a useful guide during the engineering and construction stages of the actual plant. Because of difficulties presented by limited ground space at the refinery, Fluor set up engineering and drafting personnel right at the jobsite to expedite the job. Problems were solved "on location" to conserve time.





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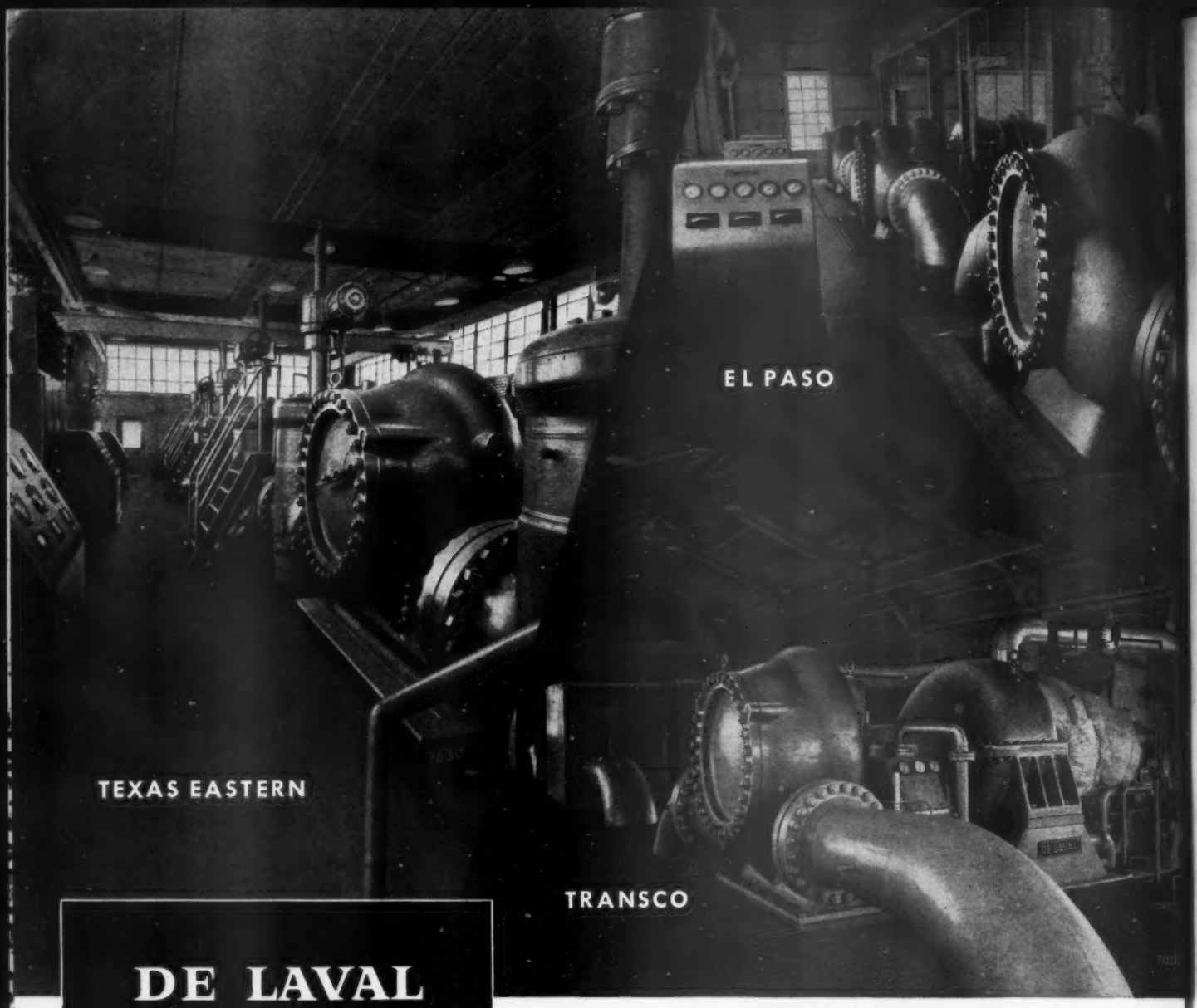

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do a big job for gas pipelines

High pressure gas transmission on pipelines calls for equipment that's dependable as well as efficient. That's why De Laval centrifugal compressors have been chosen for these and many other booster stations.

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EL PASO—These 30-inch De Laval centrifugal compressors are on the job at El Paso's Florida station. In addition, they have nine more De Laval units in use at other stations.

TEXAS EASTERN—The thirteen 2,500 hp centrifugal compressors on this company's 30-inch gas pipeline from Kosciusko, Mississippi, to Uniontown, Pennsylvania, are all De Laval.

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DESIGN ELIMINATES NEED FOR LUBRICATION

Pembina Field Boosts Canadian Reserves

Current oil boom is most noteworthy occurrence in nation's predominantly agricultural economy

THE story of Western Canada's oil play can be told in many different ways.

It can be told statistically, in the mounting flood of crude oil pouring out of 5000 wells across the Prairie provinces of Canada.

It can be told in the competitive race between the big oil searchers to corner the "hot-test" oil lands left on the continent. In the wild stock market reaction of an oil discovery stock that trades its entire capitalization in two days. Or it may be told more personally in what it's doing to the people.

Recently an oil discovery was made in Southeast Saskatchewan just a few miles north of the U.S.-North Dakota border. Westerners dropped what they were doing at the magic phrases of the official announcement—heavy wet gas blow — oil-cut muds — green condensates—rise of 55 bbl of clean, 40 deg gravity oil in a 30-minute drill stem test, the strange new street-corner language of the West.

Maps appeared as if by magic in hotel lobbies, barber shops, brokerage offices, and the now familiar pattern of excited questions broke out: "Who owns the land close by?" "What land is still open?" "Is it Crown land or freehold?" "What's the stock trading at?"

Yet just a few short years ago these people talked little but wheat and cattle; oil and the stock market were dim unrealities, vaguely associated with Texas and Wall Street.

Thats one side of the story. Here's another: Not long ago a group of mennonite farmers whose land adjoined a fast new developing oil field near Edmonton refused oil geophysical crews access to their land to conduct vital testing operations. They said: "We are farmers. We've been growing wheat for 20 years. We own our land and we don't want it all messed up by oil."

But for the great majority of Westerners who stand between these two extremes the current oil boom is the greatest thing that could have happened to their predominantly agricultural economy. The $205,000,000 budget of proposed government spending in Alberta in fiscal 1954-55 is a mighty argument in favor of oil. Not only is a big chunk of the money for the new roads, hospitals, schools, health services, etc., coming from oil, but since the Government owns the mineral rights to about 80 per cent of all the land in the province, it will likely be coming a good deal faster in the years ahead.

Royalty Problem

That raises one of the touchiest problems of the province today. Since only around 1 out of 10 Alberta farmers owns the mineral rights to his land his only direct benefit from oil is the rental he is able to charge on his acreage occupied by the oil companies for wellsites, roadways, batteries, etc. On the average this works out at around $1000-$1200 the first year and some $400 a year thereafter for as long as the well keeps producing.

This looks like mighty "small potatoes" to many of them, particularly since it represents only three to five days production revenue from an average well. Something should be done, many farmers think, to provide them with a bigger "cut" of the big oil pie. Some talk a modest royalty of 1 to 3 per cent of production from their land.

Oil companies in the midst of tremendous exploration and development program that is currently totalling some $1,000,000 a day, and looks likely to continue at a high level for many years, think any extra royalty payments should come out of the fattening government purse, not theirs. In the meantime the Canadian Petroleum Association has recently launched a series of forum-type meetings in rural districts to acquaint farmers with industry problems and improve relations.

Meanwhile oil exploration teams are having to move fast to keep their companies in the forefront of the quickening oil search. With the sum of geophysical knowledge expanding monthly and the big oil play narrowing down to the larger, well-financed companies, the competitive race for new finds has reached fever heat. Wildcatting operations—at a new peak this year—are clothed in greater secrecy than ever. Oil companies' landmen keep a packed bag ready to jump to new fields on the slightest hint of unusual activity.

One company's landmen who moved into a Southern Manitoba community some time ago to investigate the field operations of a competitive firm found themselves mysteriously "landlocked" by an unknown party who had chartered all available rental cars "for an indefinite period" before their arrival.

As this sort of thing just whets the landman's sleuthing appetite, they promptly retaliated by tying up every available lawyer in the area on lengthy land title searches. This prevented the opposition from completing their land deals with the farmers and provided them with the necessary time to bring up new cars and get into the promising new field to compete for land.

Pembina Drama

Here's a story they are still telling in Calgary and Edmonton. It concerns the now famous January Government auction of Crown reservations in the Pembina area of West-central Alberta —the auctions that saw Imperial Oil and Texaco paying $11 and $13,000,000 respectively for two 98,000-acre reservations. These are "sealed bids" and one never knows how his bid ranks with the others.

For a couple of weeks prior to the final auction date a large Canadian oil company had been drilling a most strategic well just off the northwest corner of one of the big reservations up for sale. There was no question but that the company was rushing the well to completion before auction closing date to be able to profit from the valuable drilling information. Knowledge of the geophysical formations would be of immense value in assessing the chances for oil in the adjoining land. As the drill bit penetrated to the deeper levels land scouts from competing companies began to show up. At one time two dozen of them formed a grimly attention circle around the well-site.

But the drilling company threw one

EXCLUSIVE

of the most effective blankets of secrecy around their drilling progress ever seen in the West. Operations were shut in by tarpaulin, drilling crews slept on the well-site at night and drill-cores were whisked away by car on set schedules by company officials to mysterious destinations. The fact that the well had been getting encouraging results—and finally oil—didn't come out until after the results of the sale had been announced.

The odd twist to this story is that despite all the advance information, the drilling company—which almost certainly must have entered a bid and a high one—allowed itself to be outpriced. The final chapter to this story is now being written. Five well locations have been announced for the $11,000,000 purchase. Drilling will soon get under way. As one of the officials of the oil company concerned put it recently, "we damn well got to get oil."

Boom Steps Up

The stepped-up oil play is coming at a time when it appeared as if some of the steam was starting to go out of the western oil boom. In the first half of 1953 there was a drop in the survey work and in acreage under exploration. Part of the downturn was attributed to a change in investment climate, in the amount of capital forthcoming for this kind of risk effort. A concurrent decline in stock market activity may have been a factor.

But a series of exciting discoveries in all three Prairie provinces highlighted by the major Pembina find in Alberta has sent exploration interests soaring to new peaks. As good light oil has now been discovered in Saskatchewan and Manitoba the prudent oil searcher is having to lay out his exploration dollars in three neat piles—Alberta, Saskatchewan, and Manitoba. His potential hunting grounds now stretch from Southeast Manitoba to the Foothills, from the International border to the Northwest Territories.

In their hotly competitive race for new oil, industry officials aren't stopping to worry about getting ahead of their markets.

"We can't afford to slow up," the Western Canada head of one of the Canadian "Big Four" indicated recently. "In the first place the other fellow isn't and anyway markets have a habit of catching up after a while."

The oilman explained the supply and demand picture this way. It is like the spring floods. When the pressure of dozens of new streams of water becomes too great the river overflows its banks and fans out into new fields.

In oil, when the pressure of new supplies becomes too great there is a wellhead price cut which permits an overflow into new market fields.

In Canada we have just about reached all our "easy" markets. By the time two new refineries in Washington State come on stream—one this fall, the other next summer—Canadian oil will have reached its visible market limits. It might even take a small price reduction — maybe in transportation charges — to assure the 85,000 bbl per day potential market in Washington State.

Market Outlook

Where will our oil go after that? Soon the new streams of oil pouring from the new fields will build up heavy pressure for new market outlets. The Pembina field alone boosts Canada's oil reserves another 30-40 per cent and the chief operating team in the field has already mapped out a program of 3100 wells by 1962. If all these new wells were allowed to produce at a 100 bbl per day rate they would turn out more oil than Canada's entire oil industry at the present time.

Although domestic markets have been showing a healthy 6-10 per cent rise it's obvious that they can't begin to keep pace with the anticipated rate of new oil discoveries. For instance, more wildcat wells are planned this year than in any previous year and the success ratio is steadily climbing up. Last year the industry racked up the phenomenal success ratio in Alberta of 1 successful oil or gas well in every 2 drilled.

"If the experience here is like that in Texas—and I see no reason why it shouldn't be — we'll still be drilling wildcat wells at the turn of the century," an oil geologist states.

But industry is agreed that the next drive for markets will be a rough-and-tumble affair that will necessitate a 10-15 per cent price cut and could raise a good deal of ill-feeling from industry in the important country. By looking at a map of North America it's not difficult to see where the most likely market spots are — Northern Michigan, particularly Detroit, Oregon, and as far south as California on the West Coast.

If at worst Canada is barred from further participation in the big U. S. market by artificially raised barriers of one kind or another then Canada will have no other alternative but to fall back on her last big line of market defense—Montreal in the East. With its 150,000 bbl per day refining capacity Montreal would give producers plenty of market to "chew over" for several years to come.

In the meantime, of course, there is always the possibility that rising ocean tanker rates will render Canada competitive with Near East and California crude on the West Coast as far south as San Francisco.

The Year Ahead

This year it looks as if Canadian oil can be marketed at an average rate of some 260,000 bbl per day—Canada's potential production is estimated at around 350,000 bbl per day. This market is made up of 90,000 bbl per day via the Interprovincial oil pipe line to Sarnia, Ontario; some 15,000 bbl per day dropped off in the Superior, Wisconsin, area for sale there; some 110,000 bbl per day for the three prairie provinces and for British Columbia an average for the year of around 45,000 bbl per day.

It is easy to see this rate upped to at least 315,000 bbl per day rate by early next year and 360,000 bbl per day by year end by which time a 50,000 bbl per day refinery will have come on stream near Anacortes, Wash. If a sizable price cut takes place in Canadian crude before then—a likely development—marketing could crawl over the 400,000 bbl per day rate.

By next year the Sarnia extension of the Interprovincial pipe line will be able to handle 138,000 bbl per day. Although it is unlikely there will be sufficient refining capacity in the Sarnia area to handle this (capacity now around 110,000 bbl per day), a promising market could grow up in Northern Michigan.

All three Prairie provinces produced over 80,000,000 bbl of crude oil in 1953 with a total value of $200,000,000. This represented 53 per cent of Canada's total consumption of refined petroleum products. At an anticipated average production rate this year of some 260,000 bbl per day revenue should jump to around $237,000,000. (A wellhead price cut could pare this somewhat).

Although still representing a small fraction of the over-all output, production from both Saskatchewan and Manitoba is showing the greatest percentage increase. Saskatchewan expects to produce some 5,000,000 bbl of oil this year, almost double the 1953 rate; Manitoba over 1,000,000 bbl, up some 40 per cent.

Completion of the proposed 150-mile pipe line from the Fosterton fields in the southwest corner of Saskatchewan to the Interprovincial oil pipeline will at last open up a major market for this 75-100,000,000 bbl field. Marketing of this heavy-to-medium grade crude has presented a major problem since refineries in the province have not been anxious to process it.

Now Socony-Vacuum Oil Company and associates have decided to pipe the oil to St. Paul, Minnesota, where a

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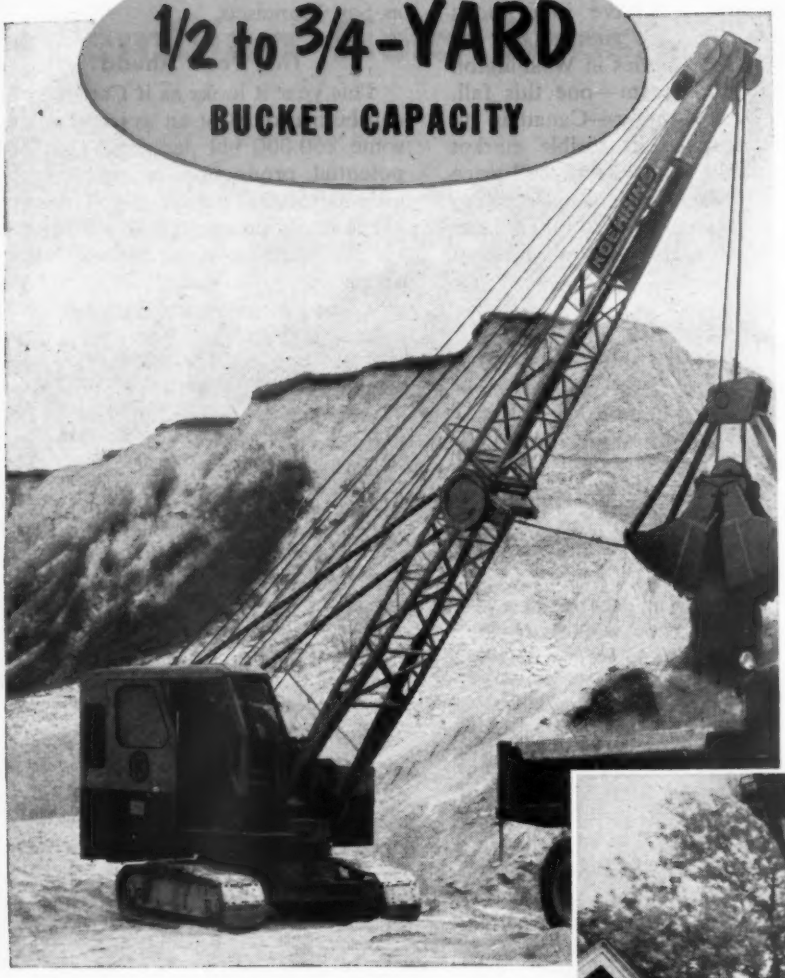
1/2 to 3/4-YARD
BUCKET CAPACITY



NEW Koehring 205 with 10 tons of lift capacity on crawlers (15 tons on rubber) has plenty of power, strength and stability to handle ½ to ¾-yard clamshell and dragline buckets on a wide work radius. Boom lengths range from 30 to 50 feet on the 205 crawler crane (25 to 55 feet on truck crane).

Crawler-mounted 205 with either standard or extra-long crawler frames, takes 16, 20 or 24-inch shoes . . . gives you ground-bearing pressure as low as 7.4 pounds per square inch. Crawlers are self-cleaning, have double-faced steel rollers, and high-carbon cast-steel shoes.

If mobility is needed the 205 is available on rubber . . . gives you the *plus* advantage of 15-ton lift capacity and 32½ m.p.h. travel speeds for clamshell, dragline and lift crane work. Converts to ½-yard shovel or hoe. Better look into this rugged new machine today.

With HEAVY-DUTY 205 you also get:

- **Full-rotating fairlead on dragline.**
- **Power boom lowering optional.**
- **Big 20-inch clutches, self-adjusting.**
- **Only 2 major shafts in upper machinery — simple, accessible.**
- **Antifriction power flow for dig, hoist, swing, and travel.**
- **4 hook rollers, eccentric adjustment.**
- **Automatic traction brakes.**
- **Independent traction, optional.**

PROVED *by 2 years of thorough field tests, Koehring 205 brings you this 10-to-15-ton capacity at only "½-yd." price. Get complete details from Koehring distributor, or write.*

To: KOEHRING COMPANY, Milwaukee 16, Wisconsin
Send us bulletin on the new heavy-duty 205.

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K405

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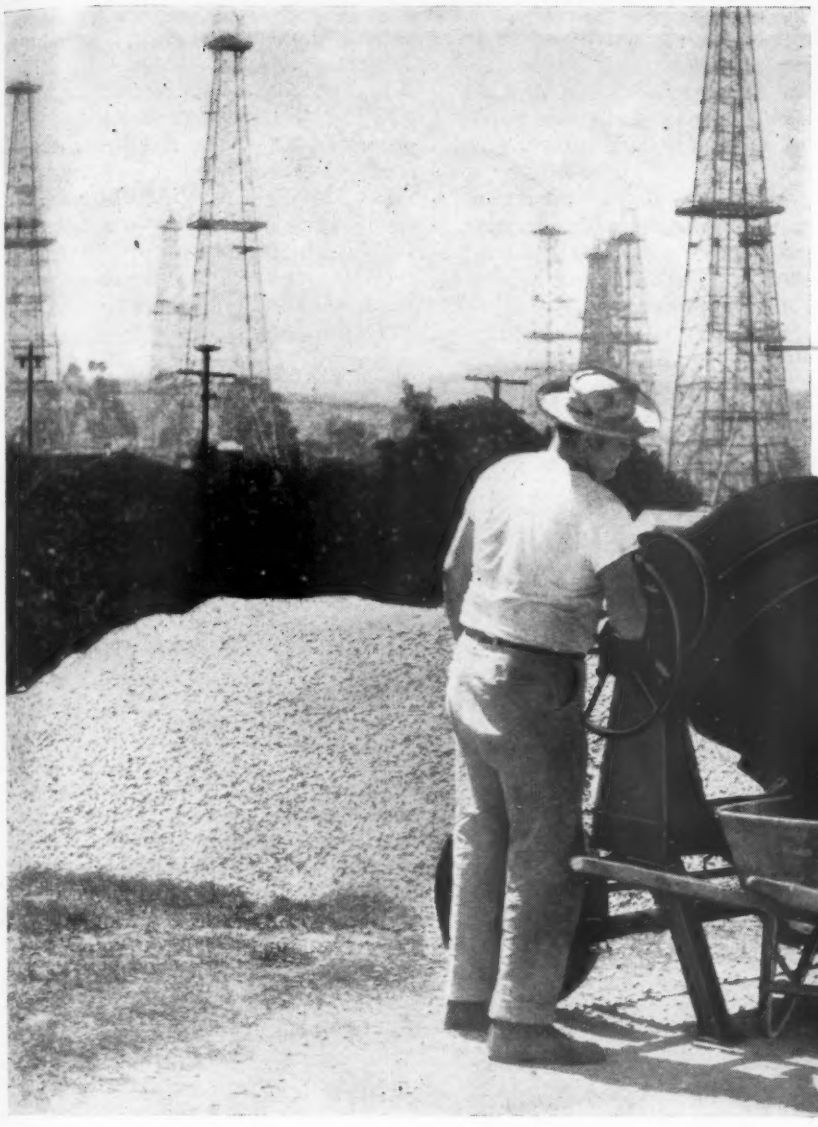

oil field "handyman"

KWIK-MIX 3½-S DANDIE® SPEEDS MIXING JOBS...

IT'S AS PORTABLE AS A WHEELBARROW....

For pouring footings, laying concrete slabs, and handling all other widely-scattered mixing jobs around refineries, yards, booster stations or drill sites, here's a portable "handyman" that does on-the-spot mixing. Kwik-Mix 3½-S Dandie produces high-quality concrete fast, at low cost, anywhere on your property.

It's portable as a wheelbarrow. Balanced light weight, low center of gravity, roller-bearing wheels and handy push-down tow-pole provide easy, one-man spotting on the job . . . and give smooth, fast towing job-to-job. Low charging height is only 43 inches. Easy-tilting drum is self-locking in any discharge position. The all-welded steel drum has reinforced lip, separate ring gear, box-section yoke for long-wearing durability. This utility-size 3½-S Dandie also has multiple V-belt drive, standard 3.4 h.p. air-cooled gas engine, antifriction bearings throughout. 3 models: side-discharge tilter, end-discharge tilter, and non-tilt.

Kwik-Mix also offers you: 6-S (shown here), 11-S, and 16-S Dandie concrete mixers; and Moto-Bug® . . . 10 cu. ft. power wheelbarrow. Ask your Kwik-Mix distributor for details . . . or write for bulletins.

mail to: KWIK-MIX COMPANY 3029 W. Concordia Milwaukee 16, Wis.

Send us bulletins on: ☐ 3½-S ☐ 6-S ☐ 11-S ☐ 16-S concrete mixers

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(Koehring Subsidiary)

☐ Also send literature on Moto-Bug power wheelbarrow.

refinery, especially designed to process the oil, is being constructed. Plan is to transport the crude in the Interprovincial oil pipe line as far as Superior, Wisconsin, and then via another line to be built in the U.S. to St. Paul. Potential production of the Fosterton area is believed to run around 15,000-20,000 bbl per day of an average 22-24 gravity oil depending on the production allowables set by the Government. Plans are to start construction of the line this summer so that first deliveries to St. Paul may be made by mid-1955.

Recent successes in Southeast Saskatchewan and Southern Manitoba is bringing stepped-up activity to these provinces. Although estimates on reserves of Saskatchewan's first light oil field—Smiley—have had to be pared down to about one-third with greater geological knowledge of the field there is still considerable drilling interest in the area. All told, government officials anticipate some $50-$60,000,000 will be spent in exploration in development in Saskatchewan this year.

A promising light oil discovery near Estevan electrified the West four weeks ago. This looks like the best quality oil east of Turner Valley. The drilling company — Canadian Gulf Oil — apparently encountered some production difficulties in later testing.

Manitoba has now 2 established light oil fields in the southern part of the province—the more recently discovered Roselea-Virden field and the older Daley field. Several of the Roselea producers have an open flow potential of well over 1000 bbl per day. There are over 100 producing wells in the province now, most of them in these 2 fields.

The biggest oil field in Western Canada was discovered in the latter part of 1953. At an oil pipe line hearing before the Alberta Petroleum and Natural Gas Conservation Board several weeks ago reserves of the Pembina field were set at anywhere from 750-900,000,000 bbl. But a couple of later wells have extended the field considerably since that date.

Effect of Pembina

The Pembina find has caused quite a shift of empnasis in wildcat drilling to the west. It is estimated that at least 60 per cent of this drilling will be west of the fifth meridian this year. Last year some 60 per cent was east of this line.

Recently Alberta's latest Cardium sand discovery was made 20 miles southwest of Pembina Cardium producers and 20 miles north-northwest of Rocky Mountain House.

In the meantime the fast expanding oil development picture is bringing more and more money into the Government coffers and working a gradual change in taxation trend—particularly in Alberta. For the current year, revenues from oil will exceed $90,000,000 in the province. This is 1½ times the total of all municipal, school and hospital taxes paid during 1953. Since Leduc discovery well came into production in February of 1947, the public treasury of Alberta, has received as a direct result of oil and gas development as at January 31, 1954, $271,955,853, which is over $35,000,000 more than the total amount paid by all the people of Alberta in municipal, school and hospital taxes combined during the same period.

Here is what Premier Manning of Alberta said of the future in his recent budget address: "It is well within the realm of possibility that in the foreseeable future revenue from further oil and gas development will be double that of the present year, in which case the increase alone from this one source would be sufficient to eliminate all present municipal, school, and hospital taxes with a balance of approximately $30,000,000 available for debt retirement or such other purposes as may be considered in the public interest."

* * *

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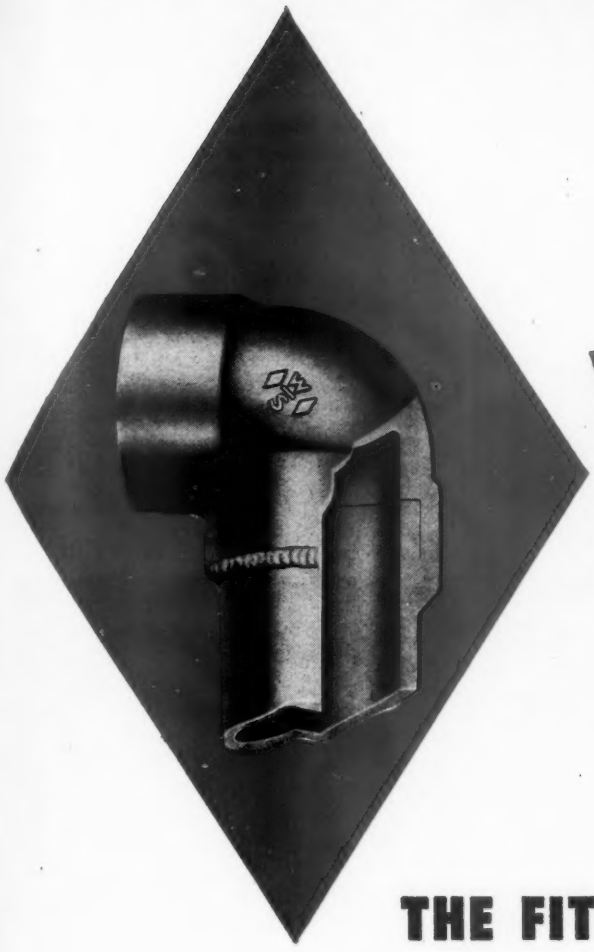

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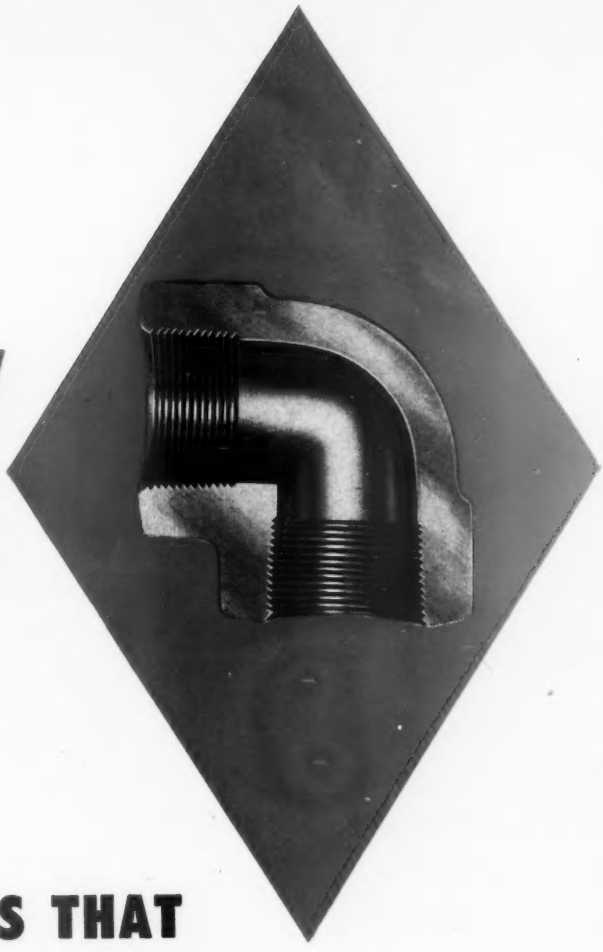
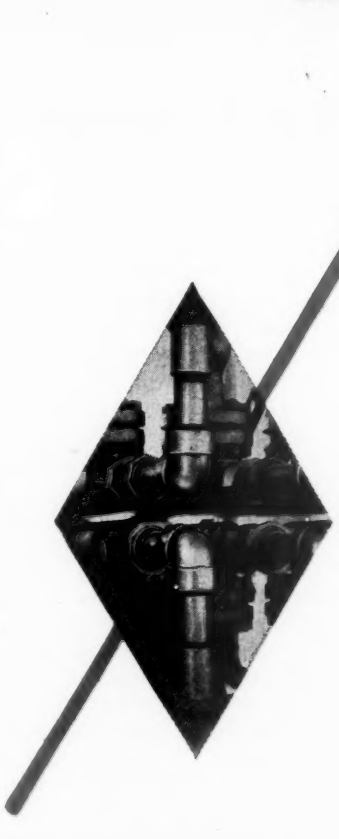


THE FITTINGS THAT CAN REALLY TAKE IT!



Every elbow, tee and cross in a high pressure piping system is a point of concentrated stress. W-S Forged Steel Fittings take this tough service in stride because they're fabricated and designed to resist pressure, heat, shock and vibration. They're drop forged of highest quality steel to produce a dense, tough, forged-fiber structure that can really take it. And careful heat treatment after forging develops the metallurgical properties of the steel to their fullest.

Notice, too, how Watson-Stillman engineers have designed extra strength into the fittings. Long bands extend well beyond the threads or sockets to provide extra reinforcement. Wall thickness is carefully calculated to put extra metal at points of severest stress.

W-S high-precision machining and rigorous inspection follow through to give you the fittings that mean stronger, tougher pipe joints. W-S Forged Steel Fittings are available in both Screw-End and Socket-Welding types in carbon, stainless and alloy steels.

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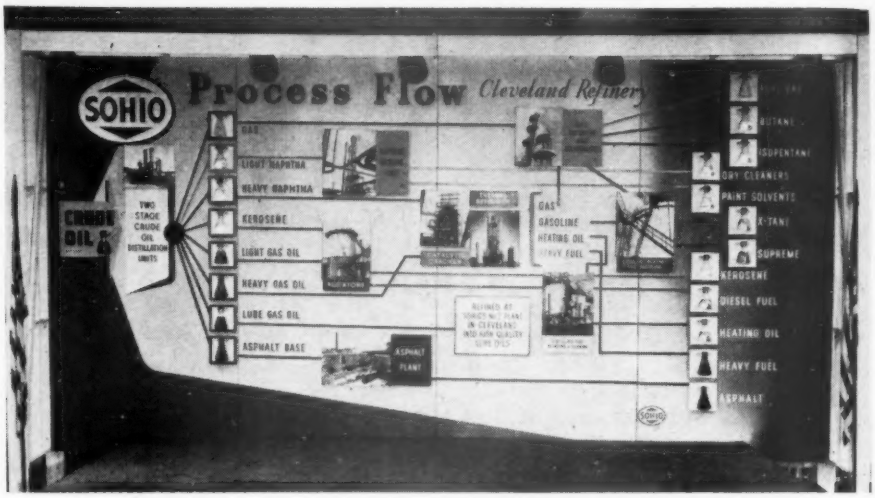
A group from John Carroll University being welcomed at the start of a plant tour.

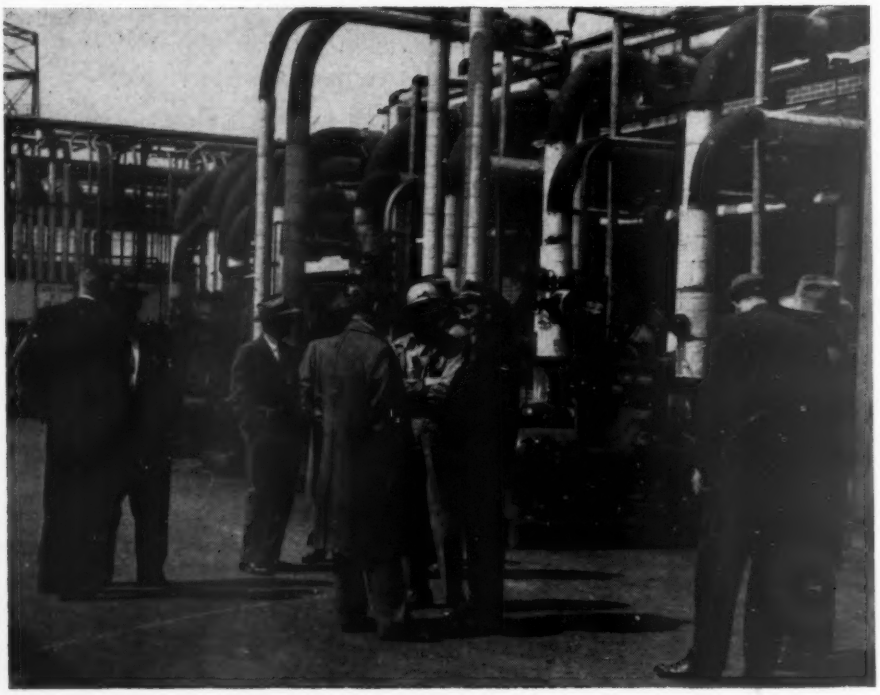


The flow chart used to describe the process operations in the refinery.

Plant Trips

Standard of Ohio builds community favor, promotes understanding with a new tool —

Plant Inspection Trips Make Friends



Cleveland fire department visitors at the new crude distillation unit.

STANDARD Oil Company (Ohio) is devoting time and attention to a program of plant inspection trips through its No. 1 Refinery in Cleveland for the benefit of the people not in the company. The company feels that in this refinery with its historical background and geographical location it has a valuable tool to use in helping promote public understanding in the area.

Plant trips have been instituted by many industries as a courtesy to special technical groups but the idea of opening a refinery to tours by a large and diverse number of people as a means of building good community relations is comparatively new.

A marketing oil company is singularly sensitive to public acceptance and

this is doubly true with a company like Sohio, which lives and sells in so concentrated an area. Standard's No. 1 Refinery in Cleveland has been a landmark in the heart of the city for 85 years and there are few people in the area who have not passed the plant or seen it from a distance and very few who do not know someone who works for the company.

It was here at No. 1 Refinery that John D. Rockefeller started the Company in 1870 and considerable oil industry history has stemmed from this location. The company decided to take advantage of these favorable circumstances and establish a plan and a group to handle plant visitors. The Industrial Relations Department of the refinery uses the Special Services Section of the plant's Engineering Department for this purpose.

There are a few simple rules:

1. Any recognized scholastic, cultural or business group or any accredited individual is welcome.
2. There are no general tours. Each group is handled entirely separately with the talk and trip tailored to their interests.
3. The tours generally last about two hours and are preferably scheduled to begin 1:30 p.m.
4. The group is brought directly to the cafeteria meeting room in the center of the refinery. Then they are seated, given a booklet on No. 1 Refinery and an official word of welcome with a short talk on the history of the industry, the company, and the refinery. The refinery is then discussed as an operation unit and as a group of people doing specific jobs. The kind of people employed and their attitude toward the company is discussed.

The speaker then turns to the flow chart immediately behind him and goes into some detail on the flow and processing of crude oil. The group is then briefed on the extent of their trip which will go from unit to unit generally in the direction of the flow of crude oil described by the flow chart. Questions are then solicited. The visitors are invited to ask anything they wish in any field, process, administration or organization. In two years and several thousand visitors, there have been many interesting questions.

The field trip itself goes to both the distillation and cracking areas of the refinery in groups of eight to ten, each in charge of a guide. This portion of the tour takes about an hour and a half. The entire group is then returned in their cars or busses to the main office where each visitor is thanked for coming to the plant and given a small souvenir of the occasion.

Among groups that have visited the plant are Boy Scouts, private girl schools, public high schools, foreign exchange students, chambers of commerce, auto dealers, Case, John Carroll, Fenn, and Western Reserve College classes, Kiwanis, Rotary and the Cleveland Fire Department. These groups have varied in size from ten to eighty and occasionally more although in many instances certain individuals have been conducted through the plant in the same manner.

The Standard Oil Company and No. 1 Refinery feels that it has profited by these trips.

* * *

General Buys J. K. Hughes

General American Oil Company, Dallas, Texas, has bought all the properties of J. K. Hughes Oil Company of Mexia, Texas, for a reported sum of $3,300,000. Property consisted of 48 producing wells with extensive royalty interests and non-productive wildcat acreage. General has a deal pending with Deep Rock Corporation involving purchase of Deep Rock's producing and other properties. General's deal with J. K. Hughes is the third property purchase made recently by the company. Purchase prior to that of Hughes was of Canadian holdings.

Thompson VIBRATING SHALE SHAKER

"Works like a Charm..." says McCUTCHEN DRILLING CO.

"... exclusive and highly useful features"

"Works like a charm," says McCutchen Drilling Company about the new THOMPSON Vibrating Shale Shaker — a statement that's echoed wherever the new Shale Shaker is in operation. The reason is that this Shale Shaker brings you all the usual THOMPSON advantages and several exclusive and highly useful features such as a SAMPLE MACHINE for quick, accurate sample taking and LIFTING BAILS for easy portability. Investigate the THOMPSON Vibrating Shale Shaker TODAY . . . it will operate efficiently and economically for you on electric, steam, gas engine or oil drive.

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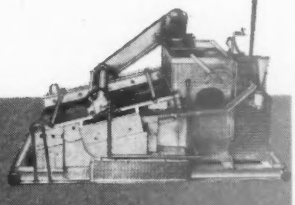
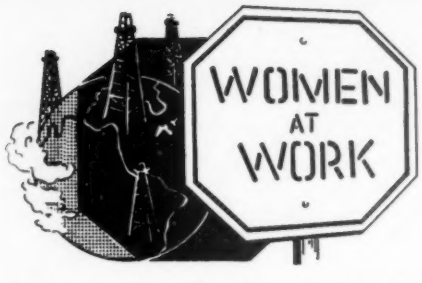


Thompson TOOL CO.
IOWA PARK, TEXAS

Western's Natalie Forte conducts company business from Shreveport

Katherine Prendergast keeps Shell products on the move.



Western Oil and Fuels' Shreveport "Boss Lady"

Natalie Forte is a little woman with a gigantic job. She is manager of the Shreveport, Louisiana, office of Western Oil and Fuel Company, which acquires and expedites movement of petroleum products to the northern states and directs the loading and dispatching of supplies by rail and water. In 1952 her office shipped 2,580,641 bbl of products totaling $9,704,988 in value.

Nat keeps her finger on the pulse of all this activity, directs the mountain of correspondence relating to it, sends and receives reports to the head office in Minneapolis, Minnesota, and travels constantly buying and selling products.

Born in Arkansas, Natalie moved to Louisiana with her parents when she was a child. She graduated from high school and business college and then went to work as assistant casher for Metropolitan Life Insurance Company. The work was too tame for her — and she left it to become purchasing agent for Western Oil and Fuel. That was in August 1936. Six years later, in the midst of a war, Nat Forte moved up to head the Shreveport office. She has maintained a warm smile and an unselfish personality that has kept her tops with employees, company executives, and customers.

W. G. Baskerville, executive vice president of Western says of her: "She has both ability and personality in more than the usual manner . . . She can hold her own in what is a field dominated by men." And an admiring employee added: "Boss Lady handles the intricate operations of her job to perfection, but she has the gift of changing her mood to a lighter side in her outside activities.

Nat's favorite hobbies are growing camellias and fishing. Almost any weekend she's off to Bisteneau or Black Lake to whet her mastery of fly fishing or casting. On one vacation she spent a week in California's mountains haunting the streams, then flew to Florida and lolled on sunny beaches for another week. Once, too, she locked up her office — literally — and sailed off on a Ouachita River barge to "learn what I was sending in reports about!" She is a member of the Noel Memorial Methodist Church, and in 1953 was Shreveport's representative for Oil Woman of the Year.

Natalie lives with her parents, a sister and brother-in-law in a beautiful house in Shreveport, but the family learned long ago not to keep dinner warm for its traveling oil executive. She might be a thousand miles from home!

Quarter Century in Oil

Lots of people around Cleveland, Ohio, think of Prendy when they think of Shell. That's because Katherine Mary Prendergast as secretary to the division manager of the Cleveland office has been Shell to dealers, jobbers, salesmen, and callers for almost a quarter of a century.

Prendy's job has been described most accurately, perhaps, as public relations. All telephone messages, all correspondence for the division manager pass through her capable hands. All incoming mail, in fact, goes first to her desk and from there is routed to its correct department. She is custodian of reams of confidential files. During the war years when the oil industry was hard pressed to meet production demands, Katherine Prendergast took on double responsibilities around the Shell office and handled them so capably that most of the duties have been left with her.

When her boss, Division Manager E. J. Griffin, is not available, she often must make a decision on an important issue and you can bet it is the one Mr. Griffin would have made.

Tall, gray-haired, gracious Miss Prendergast has, behind a twinkling Irish smile, a mind with limitless capacity for information and organization.

Katherine Prendergast is a native of Ontario, Canada. She lives in Cleveland with her sister, a registered nurse. Their home is enlivened by frequent parties, for Prendy loves to entertain. When she is not helping to push Shell sales, Prendy likes to listen to her collection of classical records, add to her English bone china and miniature china dogs, or simply enjoy a visit with her young nieces and nephews.

A Scientific Seer

Here is a woman who has probably seen the cause of more happiness and heartbreak come across her desk than almost any person in the petroleum in-

Penny Eades is Core Lab's data expert

dustry. In serving as manager of Core Laboratories, Inc.'s Data Department, Penny Eades supervises the final preparation of core analysis and logging reports from hundreds of wells every week.

Tabular and graphical analysis data, accumulated in portable field labs and in permanent type laboratories, flow into her battery of offices at 810 Core Street, Dallas, from more than 30 base points and field offices located in every oil active area in the U.S. Once the material reaches Dallas, all data are minutely cross-checked, summarized, and calculations of recoverable oil are made on productive zones. All data collected on the well are then reproduced and bound into multiple final reports to be rushed to the customer.

Regardless of Mrs. Eades' personal feelings, her vital role in petroleum reservoir engineering is predicated on cold, hard scientific fact. She has a crisp, logical mind with enough imagination not to get caught seeing single trees in these forests of data.

That is the reason she has progressed with her company since 1943, although she says: "Core Lab hired me during the war because there weren't any men left." But her associates will tell you that from the day Penny was employed to do computation on reservoir fluid analysis data she could hold her own with the best of them.

Today Mrs. Eades manages a 12-woman staff which operates as an entirely self-sufficient department, capable of processing core analysis and logging data on individual wells within a few hours. In addition, she is a stockholder in Core Lab and serves as Assistant Secretary.

Mrs. Eades graduated with a degree in mathematics from Texas University in 1936 and received a master's degree from Southern Methodist in 1941. In the interim she taught high school mathematics.

Besides building a lovely new home, she has time for Desk and Derrick activities and this year serves the Dallas club as treasurer.

She's not all mathematician. The artistic side flashes out in decorating her home, creative ceramic work, and selecting clothes that a model would envy.

Penny is a nice QED to the question — do feminine women make good executives?

★ ★ ★

"Character and courage are built through constant application and initiative. Fame and fortune smile approvingly on those who dare to laugh at disappointments and keep right on trying until they have succeeded."—*Attitudes Unlimited.*

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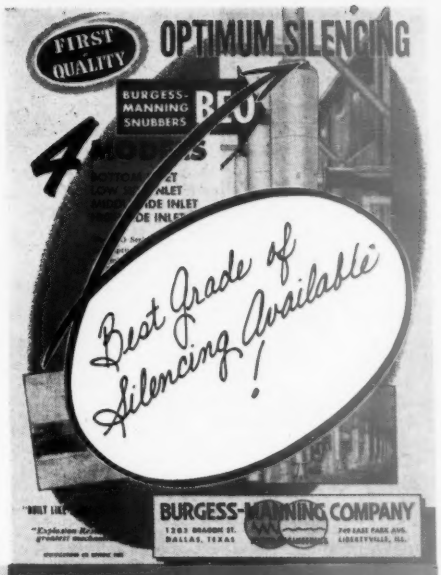

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PERSONALS

D. B. McNamara has been elected treasurer of Great Northern Oil Company. For the past 12 years he has been associated with The Chicago Corporation, serving that organization as assistant secretary and controller since 1944. He is a graduate of Southern Methodist University.

Michael Dufinecz, Jr., has been appointed a patent attorney in the development and patent department of Standard Oil Company of Indiana. He joined the research department in 1938 and since 1951 has been a patent solicitor in the development and patent department.

Francis R. Nicholas has been appointed office manager of Sun Oil Company's Fort Wayne, Indiana, sales district. Nicholas joined Sun in 1937 at the New England regional office in Boston, Massachusetts. He was office manager of the Erie, Pennsylvania, sales district until his new appointment.

Redgnald D. Bushell has been appointed as New York district manager of Ethyl Corporation. Bushell joined Ethyl in 1938 as a junior engineer. He is a graduate of the University of Michigan in 1936 with a degree in aeronautical engineering.

Dale H. Dorn has been elected president of the Forest Oil Corporation. **Forest D. Dorn,** president of the company, has been named to the newly created post of chairman of the board. **David F. Dorn** was elected to the board of directors of the Forest Oil Corporation.

Jack L. Rune has been named executive vice president of Champlin Refining Company and president of Peppers Refining Company; subsidiaries of the Chicago corporation. He succeeds **George E. Leverton** who has resigned. Rune, a graduate of the University of Kansas, was formerly with Phillips Petroleum before joining the Chicago Corporation.

Houston Texas Nomads present at the chapter's August meeting are: (front row) E. O. Bennett, construction engineer; Jack W. Roff, McEvoy Company; James Rabb, Phillips Chemical, and D. H. Manson, Asiatic Petroleum. (back row) B. K. Ayers, Jr., Stanolind; Allen F. Rhodes, McEvoy Company; F. W. Keating, Stanolind, and R. J. Young, Shell.

Bruce Scrafford has been elected president of Highland Oil Company, Esperado Mining Company, and Frio Pipe Line Company. Scrafford has been vice president of the Highland Oil Company since June 1, 1952. He succeeds Virgil A Brill as president. Scrafford joined Highland in 1952. **Robert D. Hendrickson,** former chief geologist with Highland, has been advanced to vice president of the three companies. Hendrickson came to Highland from Union Oil Company of California where he was assistant division geologist in Houston, Texas.

John W. Cahill, Jr., has been appointed editor of Sun Oil Company's employee publication. Cahill, a graduate of Southern Methodist University, is a former sports writer for the Dallas News.

Lester T. Potter, executive vice president, Lone Star Gas Company, Dallas, Texas, has been selected as Oak Cliff, Texas, Man of the Month for August by editors of the magazine, Oak Cliff. Magazine is published by the Oak Cliff Chamber of Commerce.

Rollin Eckis, has been elected vice president of Richfield Oil Corporation. Eckis has been associated with Richfield's exploration department since its formation in 1937. He was named chief geologist in 1946 in which capacity he served until his recent appointment as manager of exploration.

Evertt A. Jenkins and Harold S. Bowman have been elected vice presidents of Three States Natural Gas Company. Jenkins replaces **Henry A. Hartman** as executive in charge of production and Bowman replaces **Paul B. English,** a founder of the company and head of the land department.

Mrs. Leah R. Vinson

Mrs. Leah R. Vinson, Gulf Oil Corporation, has been elected president of the Houston Desk and Derrick Club. Houston, with 501 members, is the largest of 96 clubs in the association, which has a combined membership of approximately 8500. Los Angeles is the second largest club with 489 members and New York is third largest with 430 members. Annual convention of the association will be held in Banff, Canada, September 7 and 8.

John B. Wilbor has been advanced to manager of Socony-Vacuum Oil Company's Chicago division. He has been assistant general manager of the Chicago division since 1953, and prior to that was coordinator of supply and distribution for the Central region of Socony-Vacuum. He replaces **Bryan S. Reid** who has retired.

API Advisory Committee meeting for API project 52 was attended by (top row) H. W. Field, Atlantic Refining Company; E. O. Mattocks, API; A. P. Lien, Standard of Indiana; F. P. Richter, Socony-Vacuum Laboratories, (bottom row) A. E. Miller, Sinclair Refining Company; G. R. Lake, Union Oil Company, committee chairman, and Harry Levin, The Texas Company.

Max L. Riley, formerly chief engineer for Southwest Gas Producing Company has been elected director, vice president and general manager. He succeeds **Z. C. Ambrose** who has resigned. **P. B. Snodgrass** treasurer, has been elected a director. **John H. Crump,** director, vice president and geologist will continue in charge of the land and exploration department. **Richard F. Cox** has been appointed chief engineer. **Alfred E. Beasley** has been appointed land and exploration manager in charge of the company's district office recently opened at Lafayette, Louisiana.

W. W. Mayfield

William W. Mayfield has been elected vice president of Hope Natural Gas Company. He had been serving as manager of Consolidated System gas supplies.

Mayfield, a graduate of Purdue University, joined the Hope company in 1934 as a mechanical engineer. He was made manager of Consolidated System gas supplies in 1953.

M. J. Rathbone, president, Standard Oil Company of New Jersey, has been elected to the board of trustees of the Committee for Economic Development, a national non-profit economic research and education organization.

N. A. Rousselot, vice president and manager of the western division of Seaboard Oil Company, will be in charge of new western division headquarters established in Denver, Colorado. Other personnel include **A. W. Vitt,** manager of exploration; **H. H. Lawson,** manager of land department; **C. R. Hocker,** manager of title-record department; **C. B. Kimberlin,** manager of production; **W. A. Russell,** accounting and tax advisor, and **Fred Wade,** attorney.

L. M. Berger

Leonard M. Berger, vice president and general manager of Sinclair Cuba Oil Company, S.A., has been elected president of the company. Berger succeeds L. V. Stanford, who has been president of Sinclair Cuba since 1945.

Dr. Noyes D. Smith, director of Shell Development Company's exploration and production research laboratory in Houston, Texas, has been elected a vice president of the company.

Dr. Smith, a graduate of the University of Texas and Harvard, joined Shell as a seismologist in 1935. He became research manager of the technical department in 1951 and was promoted to the directorship in 1953.

Lloyd F. Bayer and **Fero Williams** have been appointed senior vice presidents of Tide Water Associated Oil Company. Bayer has been with Tide Water since October 1916 and for several years has served as vice president in charge of the company's western division. Williams was elected a director in 1952.

John T. McDowell has been elected vice president and general manager of Cities Service Oil Company, Ltd., McDowell will make his headquarters at company offices in Toronto, Canada.

C. E. Beecher has been elected president of Drilling Research, Inc., to succeed **C. P. Dimit,** who resigned due to ill health. Drilling Research, Inc., was formed to develop new methods and apparatus for drilling oil and gas wells and currently is preparing to field test a new drilling apparatus.

James T. Maher has been appointed general staff assistant in public relations for The Texas Company. Maher was formerly a member of the public relations department of Cunningham and Walsh, Inc.

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Company Reports Show Contrasting Mid-Year Profits

Ohio Oil Company's net income for the 6 months of 1954 ending June 30 was $19,493,031 as compared to $20,399,931 for the same period of 1953.

Venezuelan Petroleum Company and its subsidiaries have reported a gross income of $16,222,826 for the first 6 months of 1954 compared with $10,125,014 for a similar period of 1953. Net income was $1,602,150 as compared to $1,232,012.

Tide Water Associated Oil Company's net income for the first half of 1954 was $18,167,000 compared to $17,487,000 for a similar period in 1953.

Net income for The Louisiana Land and Exploration Company for the first 6 months of 1954 was $6,832,378 compared to $5,037,848 for a like period in 1953. Gross was $12,415,961 to $10,768,772.

Gross income for Sinclair Oil Corporation and subsidiaries for the first half of 1954 was $499,072,164 compared to $448,685,921 for a like period of 1953. Net income was $36,515,125 compared to $30,279,126.

Standard Oil Company of California has reported a net income of $104,043,923 for the first 6 months of 1954. Earnings in 1953 were $91,373,736.

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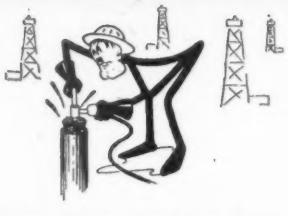

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Net earnings of Deep Rock Oil Corporation for first half of 1954 was $327,000 compared with $618,000 for same period in 1953.

Bishop Oil Company's net income for first 6 months of 1954 was $87,616 as compared to $96,066 for a similar period of 1953. Gross income was $889,962 as compared to $843,204.

Net income of Panhandle Oil Corporation for first half of 1954 was $6,743,748 as compared to $6,208,169 for the same period in 1953. Net income was $503,767 compared with $393,812.

Seaboard Oil Company of Delaware had a net earning of $3,423,510 as compared with a net of $3,420,751 for the same period in 1953.

Socony-Vacuum Oil Company Inc., has announced an estimated net income of $88,000,000 after federal taxes. Income for the same period of 1953 stood at the same figure.

Sunray Oil Corporation has reported a net income of $11,522,813 for the first 6 months of 1954. Net income for the similar period in 1953 was $13,979,224.

Plymouth Oil Company has reported earnings of $3,349,639 for the first half of 1954 as compared with $4,559,494 for a similar period in 1953.

Net earnings of Union Oil Company of California for the first 6 months of 1954 totaled $17,687,935, compared with $17,807,464 in the 1953 first half. Sales volume for the first half of 1954 was $177,557,558 as compared with $156,271,813 for a like period in 1953.

Mid-Continent Petroleum Corporation has reported a gross income of $83,931,105 for the first half of 1954 as compared to $85,229,080 for a similar period in 1953. Net income was up from $7,166,567 to $7,173,866.

Net income of Richfield Oil Corporation for the first half of 1954 was $12,393,626 compared to $12,989,344 for same period of 1953. Gross income was $102,259,736 compared to $99,461,592.

Skelly Oil Company's gross income for first 6 months of 1954 was $104,633,540 as compared to $105,467,698 for a similar period of 1953. Net income was $14,183,889 as compared with $13,723,275.

Standard of Ohio had a net income of $8,044,035 for the first 6 months of 1954 as compared to $8,506,364 for a like period in 1953. Income before taxes was $14,369,035 as compared to $17,806,364 for 1953.

Estimated consolidated net income of Signal Oil and Gas, for the 6 months of 1954 ended June 30, totaled $5,094,099 as compared with $4,233,408 for the first half of 1953.

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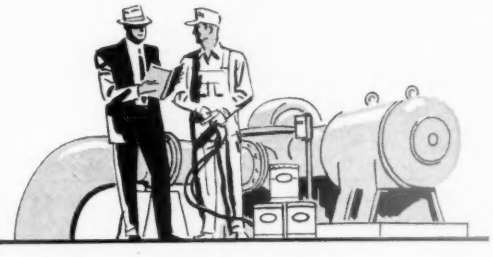

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DEATHS

Merle J. Trees, chairman of the board of Chicago Bridge and Iron Company, died August 6 in Chicago, Illinois. Trees started as an estimator and contractor for Chicago Bridge in 1910.

William Gasper de Kotch, well known California oilman died of a heart attack July 30 in Los Angeles.

Robert B. Thompson, geologist with Hill and Hill, Inc., died July 24 at Fort Worth, Texas. Thompson was formerly with Danciger Oil and Refining Company before joining Hill and Hill.

Edmond L. Lorehn, executive vice president of Cameron Iron Works, died in Houston, Texas. Loehrn joined the company in 1920. He was Cameron's vice president and general manager before named executive vice president in 1950.

Lloyd Williamson, independent oil producer and president of the Mascot Oil Company and the Lakeport Petroleum Company, died in Los Angeles, California. He was a director and past president of the Oil Producer's Agency of California and a director of the Independent Petroleum Association of America.

Walter L. McCloy, Jr., Sohio Oil Company's northwest division superintendent of operations, Billings, Montana, died of a heart attack. McCloy was one of Sohio's oldest employees having been employed in 1939. He held many supervisory positions throughout the company before being transferred to Billings in June 1953 from Oklahoma City.

Robert C. Thompson, chief engineer of the control division, Electric Machinery Manufacturing Company, died July 14 in Minneapolis. Thompson, a graduate of the University of North Dakota, joined Electric in 1941.

Harry Fuller, retired Sinclair Oil Company executive, died August 8 in Miami Beach, Florida. Fuller joined the company in 1919 in the wholesale department. He became vice president for wholesale sales in 1950.

DeWitt Knox, former secretary-treasurer and a director of the Macmillan Petroleum Corporation died August 13, 1954, at Seaside Memorial Hospital, Long Beach, California. Knox was with Macmillan for 26 years.

Lawrence Vander Leck, California oil man, died at his home in Altadena, California, on July 15, 1954. Vander Leck was president of the San Jose Development Company, a general partner in San Jose Oil Company, a director of Oil Producers Agency of California, and a vice president of Holly Development Company.

H. S. Graver, Sr., product manager for the bulk tank division of Graver Tank and Manufacturing Company, Inc., died in Chicago, Illinois, on August 6, 1954. He had been with the company 50 years.

Clifford H. Brown, Sr., Dallas, Texas, independent oil operator, died August 19, 1954, in Jacksonville, Florida, while on vacation. Brown was president of Brown Land and Royalty Company and formerly had been associated with Tex Oil Company. Brown had been district manager of the Continental Supply Company before becoming an independent operator in 1917. He organized the Mid-Continent Supply Company in 1926.

James D. Long, former superintendent for Republic Production Company and later The Texas Company, died in Dallas, Texas. He was an independent oil operator in Ohio, Indiana, and Illinois before moving to Texas.

H. A. Swem, vice president and general manager of Texas Gulf Sulfur Company, died in Newgulf, Texas, August 8, 1954. He had been with the company since 1919.

John A. Bates, Gulf Oil Corporation production department member, died August 8, 1954 in Sapulpa, Oklahoma.

Leo Brammer, receiver for Tulsa Oil Products Company, Tulsa, Oklahoma, died recently in Tulsa, Oklahoma.

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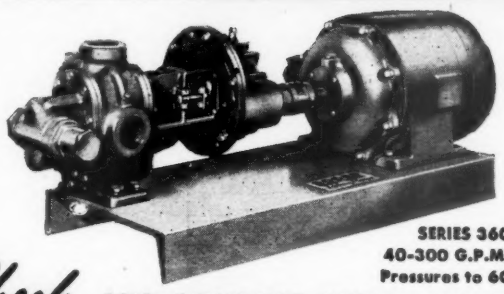

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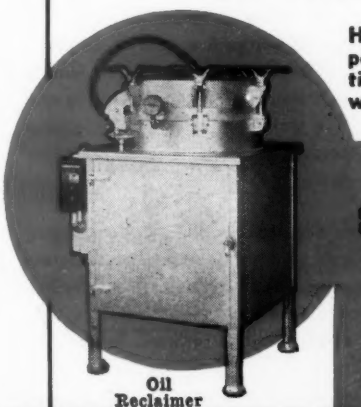

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2 **Remove Rust and Scale:** To facilitate inspection and repair, rust and scale should be removed immediately after alkaline cleaning. Use of an inhibited acidic material such as Oakite Compound No. 32 assures fast, thorough job . . . safety to metal surfaces. Follow with thorough rinse.

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BOOKS ★

Human Behavior in Industry, *by William W. Finlay, A. Q. Sartain, Willis M. Tate, McGraw-Hill Book Company, 303 West 42nd Street, New York 36, New York. Pages, 247. Price, $4.00.*

This book should be required reading for all people who deal with other people! It is not only a guide for management, as its title would indicate. It is also applicable to any group activity "that requires the efforts of more than one person."

The authors (Finlay—the engineer, director of the Business Institute at Antioch College; Sartain—the psychologist, head of the psychology department at SMU; and Tate—the sociologist, newly elected president of SMU) have all been teachers in the Institute of a Management, a course designed to foster good personnel relations in industry, sponsored by Southern Methodist University in Dallas. "Human Behavior" is the outgrowth of these sessions.

Among its 20 chapters are discussed such pertinent subjects as "Basic Motives of Workers," "The Use and Misuse of Authority," "Employee Counseling," "Dealing With the Union," "Making Work Attractive and Significant," "Problems of Discipline."

There is nothing actually new in the book, but the "something old" is viewed with freshness, clarity and understanding by authors who are more than adequately equipped to handle their subject.

On People: "The things that are ours have special attraction—*our* children, *our* church, *our* city—. . . If you would understand a person you must understand how he *feels*. . . . These things do not apply to *somebody else;* they apply to all of us, regardless of rank, age, sex, I.Q., education, or anything else. . . . We are all strongly inclined to come to the conclusions we really want to come to."

On Employers: "The manager . . . needs emotional control and balance. He must act decisively and wisely . . . he ought to be willing to do anything that he asks an employee to do. . . . Inform people about the things that affect them."

On Selecting Employees: "Even the best selection programs . . . have limitations. Selection is . . . a matter of plaving the odds. . . . Be careful not to oversell the job . . . Most employers have a real need for a lot of ordinary folks and a few places for the unusually bright and capable. . . ."

On Public Relations: "The inescapable truth is that public relations is everybody's job. . . . There is a definite relationship between a company's human relations and its public relations. . . . All the things one does and all the things one says are identified with the company."

Voluntary Pooling and Unitization, *by Leo J. Hoffman, Matthew Bender and Company, Inc., Albany 1, New York. Pages, 336. Price, $12.*

Written as a complete legal guide, Voluntary Pooling and Unitization resolves many questions that have arisen concerning this newest and significant development in the producing branch of the petroleum industry. It answers questions that arise when the lease does not carry an express provision for pooling and unitization. It explains principles, statutes, terms, tells how the problem is affected by various court interpretations, how it differs in various states, the lessee's position, the effect in case of surrender, the effect of partition, how multiple community leases work. It explains the lease pooling clause and the conventional pooling or unitization agreement itself and explains the theory and practice of equitable pooling or unitization.

The author, as an attorney for an oil company that has negotiated or entered into numerous community leases, pooling agreements and unitization agreements, speaks with authority on his subject. He holds BA and LLB degrees and a Masters of Laws in Oil and Gas.

1954 Tulane Tax Institute, *Third Annual Edition, Matthew Bender and Company, Albany 1, New York. Pages, 588. Price, $10.*

A tax institute is held each year at Tulane University, and this book presents the 18 subjects covered at the third meeting. The subjects were selected for their immediate and practical importance and each is discussed by an eminent tax authority.

Subjects of interest to the oil industry covered in the book include: Deferred Compensation of Executives," by John P. Allison; "The Outlook for Federal Taxes and Expenditures," by Elbert Parr Tuttle; "Planning for Maximum Use of Net Operating Loss Deduction," by Mark E. Richardson; "Recent Developments in Oil and Gas Taxation," by Lee Hill; "The Receipt of an Economic Interest in an Oil and Gas Property in Return for Services Rendered," By Marvin K. Collie, and "Maximum Tax Benefit from Percentage Depletion," by Bruce H. Johnson.

LAUGH with BARNEY

Speaker: Is there any man in the house who would let his wife be slandered and say nothing? If so, please stand up.

A meek little man rose to his feet.

Speaker: Do you mean that you would let your wife be slandered and not do anything about it?"

Meek Little Man: Oh, pardon me, I though you said slaughtered.

He wanted to surprise his wife, so he brought home a beautiful skunk coat for her birthday.

As his wife opened the box and fondly pressed the contents to her bosom, she exclaimed: "Imagine getting a gorgeous coat like this from such a disgusting creature!"

Her husband winced once as he said sadly, "Oh, well, I didn't expect you to thank me for it."

It has been said that the first Scotchman to use free air at a service station blew out four tires.

Two cowboys were about to leave for a trip to the Arizona desert. One of them was talking to a stranger who inquired about their equipment.

"My pardner and me are travelin' light. He's taking nutin' but whiskey for rattlesnake bites.

"And what are you taking?"

"Two rattlesnakes!"

A musician is a man who, when he hears a soprano voice singing in the bathtub, puts his ear to the keyhole.

Gentleman—A wolf with patience.

A doctor had an urgent call from a gentleman who reported that his small son had sucked all the ink out of a fountain pen and swallowed it.

"All right, I'll come right over at once," replied the doctor. "What have you been doing in the meantime?"

And the man answered: "Using a pencil."

St. Peter heard a knock at the door, opened it, and there stood a young man.

"Where are you from" said St. Peter.

"Texas."

"Come on in, but you won't like it here."

Wife to husband: You keep quiet. When I want your opinion, I'll give it to you."

An Australian was trying to impress a Texan with the wonders of his country, but then the Texan saw a kangaroo. Drawled the man from the Lone Star State: "Ah'll grant you one thing, that's for sure. Your grasshoppers are bigger'n ours."

The new father gazed through the glass window at the hospital nursery. Every baby was crying.

"What's the matter with them?" he asked the nurse.

"Suppose you were only a few days old, out of a job, and owed the government $2,050 . . . you'd cry to," she answered.

The assembly hall was drinking in the speaker's powerful philosophies and words.

"He who gives in when he is wrong, is wise," he shouted.

"But he who gives in when he is right —is—"

"Married!" rang out a voice from the back of the room.

She: You remind me of the ocean.

He: On account of being so wild, magnificent, and romantic?

She: No—because you make me sick.

Brown had put on a paunch. He had gone on a diet and had harangued everyone about it at every opportunity. Finally one day one of his friends caught him in a restaurant eating a tremendous steak. "What's the idea? demanded the friend. "I thought you were on a diet."

"I am." said Brown with a guilty look on his face, "this is just to give me the strength to continue it!"

The wife wanted to do something during the day, so at breakfast she asked her husband for ten dollars.

"Money, money, money!" he shouted. "Every day of the week you want more money. If you ask me I think you need brains more than you need money."

"Perhaps so," his wife agreed, "but I asked you for what I thought you had the most of."

Doctor (arranging patient on operating table): "I'll be perfectly frank and tell you that four out of five patients die under this operation. Is there anything I can do for you before I begin?"

Patient: "Yes. help me on with my shoes and pants."

"Excuse me, but I'm in a hurry! You've had that phone 20 minutes and haven't said a word."

"I'm talking to my wife."

Flattery, like perfume, should be smelled but not swallowed.

A man has reached middle age when the babe he winks at thinks he has something in his eye.

A tramp was sleeping on the ground of a country club golf course when he was awakened by the club's secretary poking him in the ribs with a mashie. "Get off this property and stay off," the official scowled. "And who are you?" inquired the bum. "I'm secretary of this club," the the official said. "Well," replied the ragged fellow, "this is a fine way to get new members."

A new maid in the home of a Texas millionaire was telling a girl friend how swanky and wealthy were her new employers. "They're so rich and high class," she said, "they even have their own faucets in the bathroom. One is marked H and the other C."

A hillbilly, out hunting at night, came upon a railroad track and waved his lantern at an approaching train and brought it to a grinding halt. When the engineer frantically asked the trouble, the mountain boy inquired: "You wanta buy a raccoon?" The engineer's reply was an explosive blast of not-so-nice language. "Well," drawled the hillbilly, "you needn't get excited about it. Heck, I ain't even caught the 'coon yet."

"I used to be a production engineer, and I liked it. Always somethin' to do- trouble to iron out- somethin' keepin' me on my toes always. Then I started usin' LANE-WELLS PACKERS- everything changed- no trouble- no foul-ups- everything peaceful. I tell you, Doc', this inactivity is drivin' me crazy!
Lowmac
CP-701

CEC increases the scope of industrial mass spectrometry through two great instruments for process monitoring and control

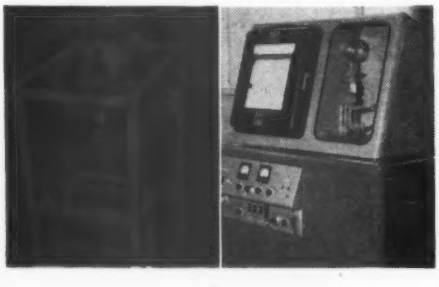
Consolidated's Model 21-610 mass-spectrometer and its companion, the new Model 21-620, far excel all other instruments of comparable price in performance capabilities and reliability in industrial environment. The extreme sensitivity of the 21-610—accurate to a few parts per million—qualify it for highly critical purity studies as well as process monitoring and control applications. Fitted with an accessory hand-held probe, either model serves as a leak detector for any gas within its mass-range. The 21-620's resolving power up to mass 150 further extends the applicability of an industrial mass-spectrometer to research laboratories and medical centers, as well as to plants of chemical, petro-chemical, petroleum and gas industries. Nearly identical in appearance, the 21-610 features the Diatron ion analyzer and the 21-620, a new cycloidal focusing analyzer.

21-620 Except for slightly less sensitivity, the 21-620 has all the capabilities of the 21-610 plus many others. Where the task is to analyze "heavy" gases or liquids, either in plant locations or in the laboratory, the 21-620 process monitor mass-spectrometer is the ideal control instrument.

21-610 The 21-610 is completely self-contained, needing only 110 volts and a small quantity of cooling water for operation. Moderately priced, easily movable, and economical to operate, the 21-610 is industry's ideal instrument for chemical research, process control and leak detection.

CEC Service Engineers quick change of ion analyzers (right) adds flexibility to Consolidated's two process monitoring mass-spectrometers. A cycloidal focusing analyzer assembly of the 21-620 type is being mounted in the vacuum rack in place of the Diatron analyzer of the 21-610.

The basic instrument can be augmented by many available accessories, thus broadening its application scope. At the far right, are a gas or light-liquid sample inlet system and chart recorder.



Consolidated Engineering
CORPORATION
300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service through **CEC INSTRUMENTS, INC.,** *a subsidiary with offices in: Pasadena, Atlanta, Chicago, Dallas, Detroit, New York, Philadelphia, Washington, D. C.*

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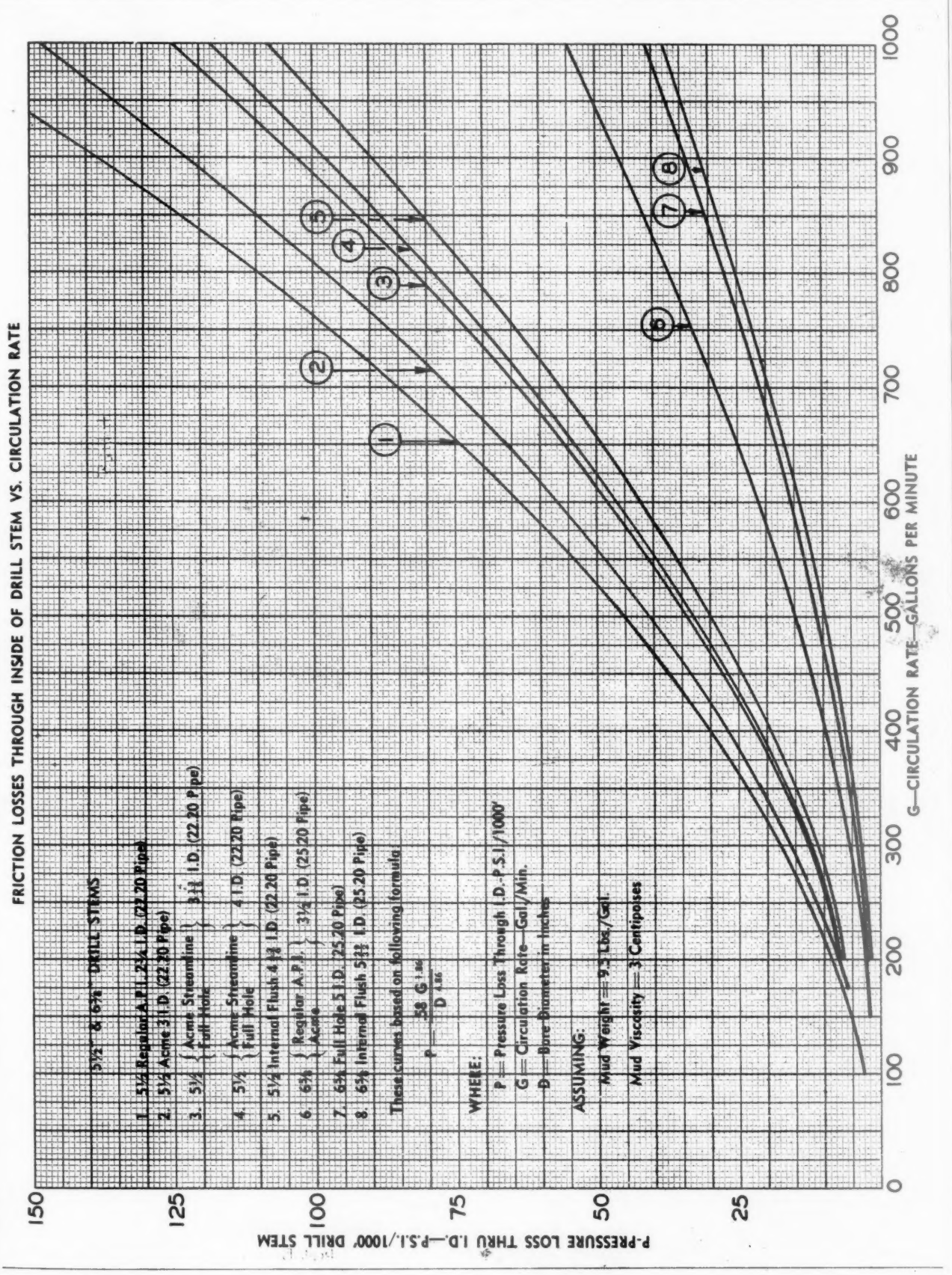
Investigate the application of industrial mass-spectrometry to your business. For full details about CEC's two companion process monitoring mass-spectrometers, send for Bulletin CEC 1824A-X5.

DRILLING HYDRAULICS



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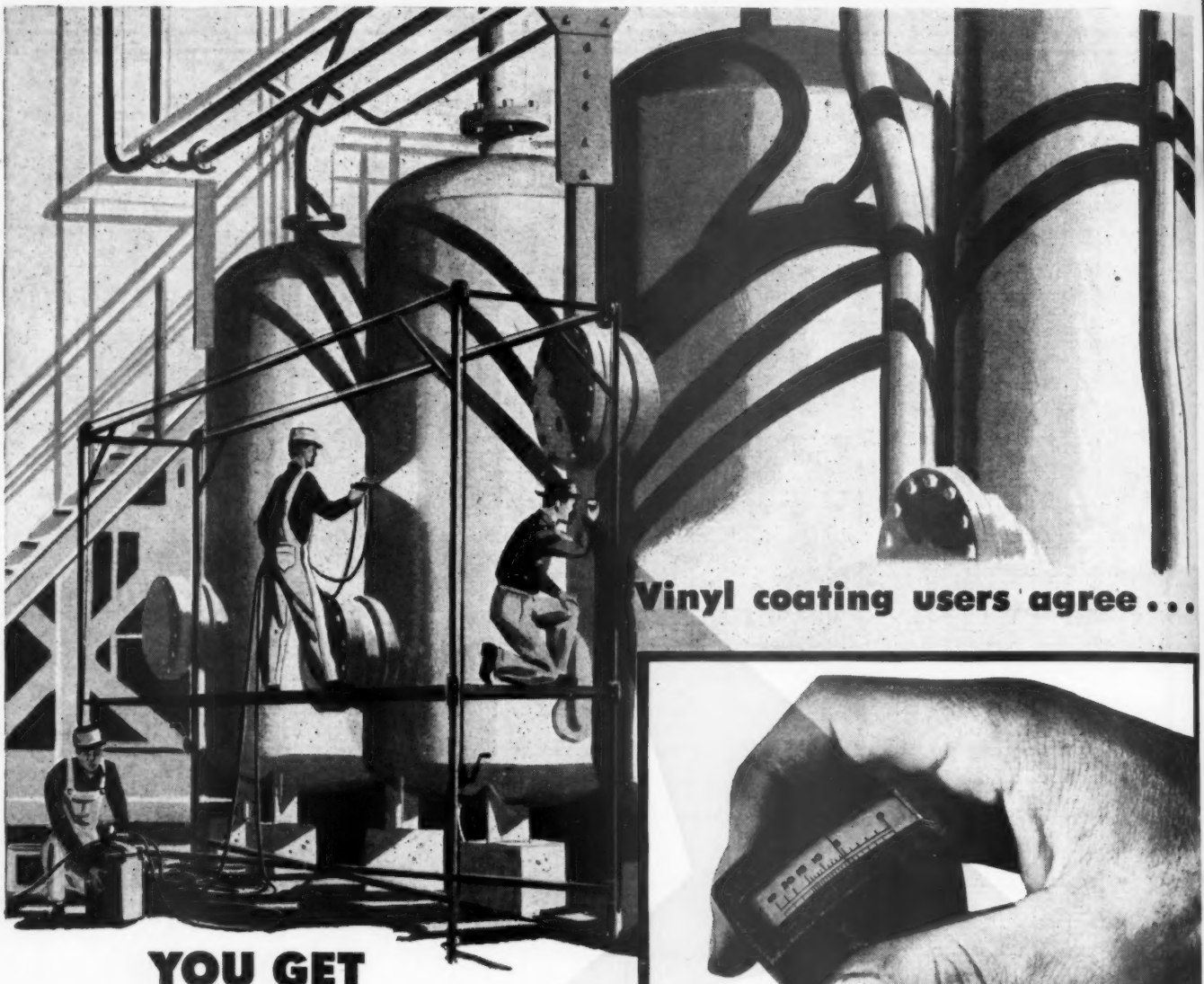

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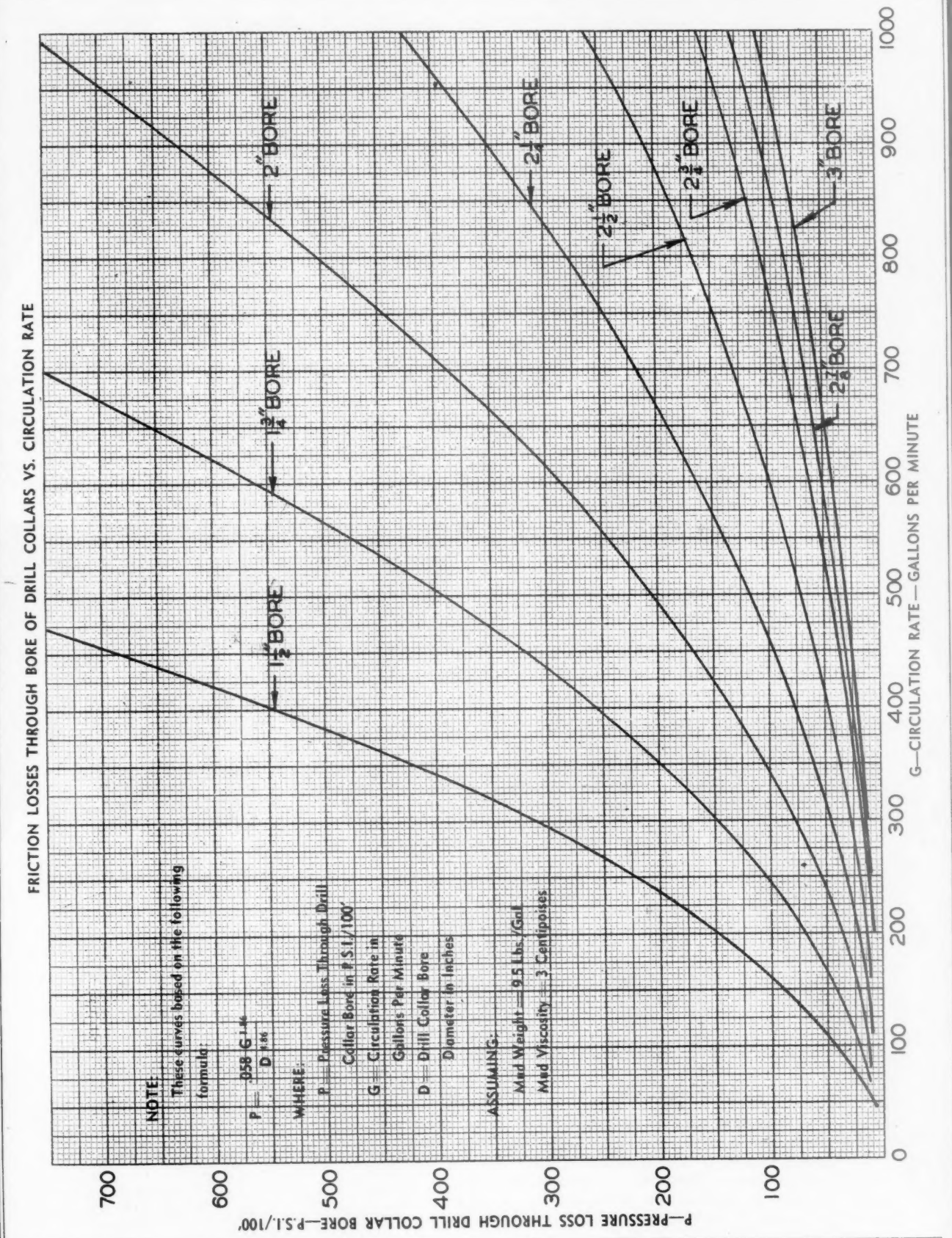
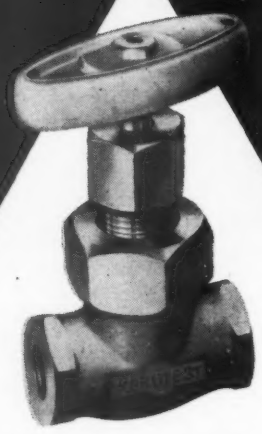
Write today for the AMERCOAT 33 Technical Bulletin which gives a complete description of the coating's chemical and physical properties.

DRILLING HYDRAULICS

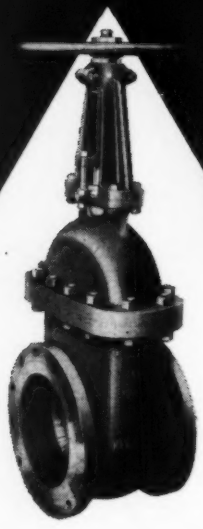


Courtesy of Hughes Tool Company

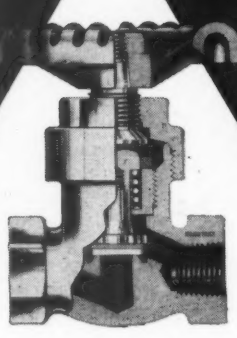
KEROTEST



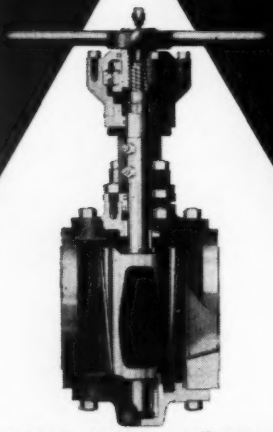
NEEDLE VALVES — MODEL N-20
Kerotest Needle Valves are of forged steel, union bonnet construction. They are available in Carbon and Stainless Steels for high pressure and corrosive services. Stellite swivel tips are available on customer specification. They have countless applications throughout oil refineries, chemical and other industrial plants. A quality valve for long life and service.



GATE VALVES — 12" SERIES 150
Manufactured in accordance with A.S.A. and A.P.I. specifications in all pressure classes and in diameters from 2" to 24" inclusive. Applications in oil fields, refineries, and other gas and oil production installations. Continuous engineering improvements and forty years of experience are built into these valves.



R-42 VALVES — FEMALE PIPE CONNECTION
An excellent diaphragm packless valve for installations that require this type of design. This valve is manufactured in both Steel and Brass so that it can be used for a host of applications in laboratories, gas odorizing, high aromatics, and other products where packed valves may leak. Pressure ratings from 500 to 2000 pounds per square inch are available. Manufactured in quick opening models for uses where speed of operation is essential.



TWIN SEAL VALVES — 6" SERIES 150
The Twin Seal is a non-lubricated, high flow, plug valve designed and engineered for gaseous and volatile liquid service. Thousands of these valves are already installed throughout the United States. A positive, vapor-tight shut-off of both ports of the valve is assured. Face to face dimensions of these valves are equivalent to comparable size steel Gate Valves. A valve with proven field application.

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PROPERTIES OF CAST STAINLESS STEELS

ALLOY DESIGNATIONS					NOMINAL ANALYSES						
Type	ACI	AISI*	SAE*	ASTM	C	Cr	Ni	Si	Mo	Special	
12CrLC	CA-15	410	60410	A296-49T Grade CA-15	.10	12.5	.5	.75			
12CrMC	CA-40	420	60420		.20	12.5	<.5	.75			
12CrHC	CA-40	420	60420		.30	12.5	<.5	.75			
12Cr-Tool Steel					1.5	12.5		.5	1	Co<1	V 1
18Cr	CB-30	442	60442	A296-49T Grade CB-30	.25	18	<.5	.75			
28Cr	CC-50 HC	446	60446	A296-49T Grade CC-50 A297-49T Grade HC	.30	28	<1	.75			
28-3	CC-50 HC	446	60446	A296-49T Grade CC-50 A297-49T Grade HC	.30	28	3	.75			
28-3Mo	CD-10M	329			<.10	28	3	.75	1.5		
28-3HC					1.00	28.0	3.0	.75			
18-8S	CF-8	304	60304	A296-49T Grade CF-8	<.08	19	9	1.25			
18-8SCb	CF-8C	347	60347	A296-49T Grade CF-8C	<.08	19	9	1.25		Cb8xC (1.0 Max)	
18-8SMo	CF-8M	316	60316	A296-49T Grade CF-8M	<.08	19	10	1.25	2.5		
18-8FM	CF-16F	303	60303	A296-49T Grade CF-16F	<.16	19	9	1.25	<1.5	Se .25	
18-8	CF-20	302	60302	A296-49T Grade CF-20	<.20	19	9	1.25			
20-10	CG-12	307–308	60307	A296-49T Grade CG-12	<.12	20.5	10.5	1.25			
8-20	CM-25	325			.25	9	20	1.5			
18-8MoCuBe					<.07	19	10	3	3	Cu 2	Be .15
20-25Mo	CN-7M				<.10	20	25	1	1.5		
20-29MoCu	CN-7MCu				<.07	20	29	1	3.5	Cu 4	
25-12S	CH-10			A296-49T Grade CH-10	<.10	25	12	1			
25-12SCb	CH-10C				<.10	25	12	1		Cb8xC (1.0 Max)	
25-12SMo	CH-10M				<.10	25	12	1	2.5		
25-12	HH	309	70309	A297-49T Grade HH B190-50 Type #1 & #2	.30	25	12	1.5	<.5		
23-12W					.20	23	12	1.5	<.5	W 3	
29-9	HE	312	70312	A297-49T Grade HE A296-49T Grade CE-30	.30	29	9	1.5	<.5		
25-20	HK	310	70310	A297-49T Grade HK	.30	25	20	1.5	<.5		
15-35	HT HU	330	70330	A297-49TGradeHTorHU B207-50	.40	15	35	2	<.5		
15-65	HW	335	70335	A297-49TGradeHWorHX	.40	15	65	2	<.5		

** The AISI and SAE type Nos. cover equivalent chemical analyses for wrought products.*

Alloy Type	12CrLC	12CrMc	12CrHC	12Cr-Tool Steel	18Cr	28Cr	28-3	28-3Mo	28-3HC	18-8S	18-8SCb	18-SMO	18-8FM	18-8	20-10	8-20	18-8MoCuBe	20-25Mo	20-29MoCu	25-12S	25-12SCb	25-12SMo	25-12	23-12W	29-9	25-20	15-35	15-65
CA Designation	14S	14I	14H	15A	16	19	19A	19AM	19AH	175*	175Cb	175M	171L	17**	20-10***	18	V28	21A	FA30†	22S	22SCb	22SM	23††	22W	22P††	KHC3††	20†††	21†††

*May be supplied with .03% carbon. **Mo may be added as required. ***Cb or Ta may be added as required - also allow may be supplied with (.08% carbon. †Licensed under Durimet patents. ††Supplied with (.20% carbon for corrosive use. †††% of Ni may be varied as per specification

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Performance records prove that Wiggins Double Pontoon Floating Roofs soon pay for themselves in liquid conserved. Only Wiggins Double Pontoon Floating Roofs have every important feature for maximum conservation . . . safest operation . . . low-cost maintenance.

Triple Seal increases conservation savings and adds extra safety.

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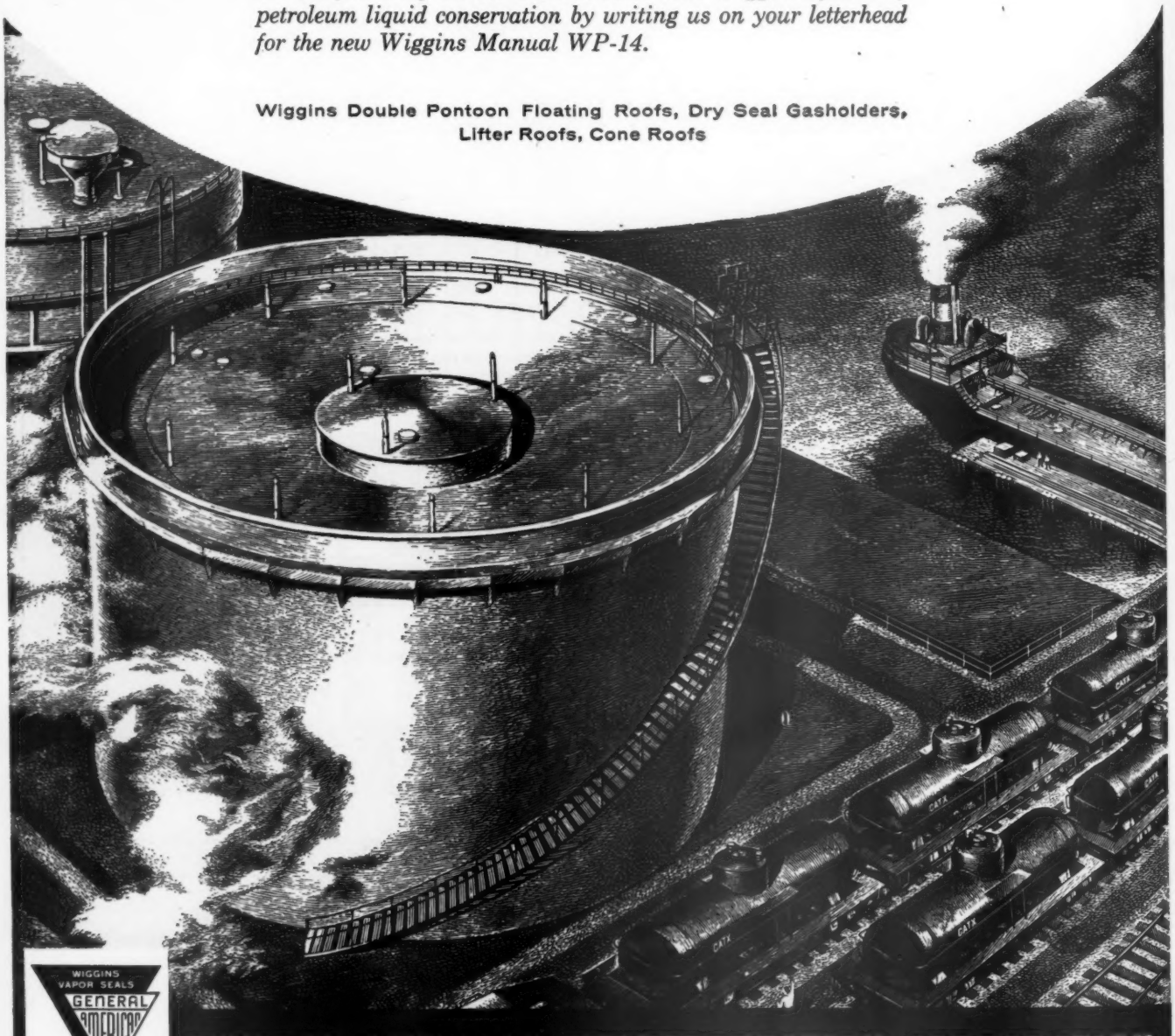

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GENERAL AMERICAN TRANSPORTATION CORPORATION

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PROPERTIES OF CAST STAINLESS STEELS

Type	TYPICAL MECHANICAL PROPERTIES AT ROOM TEMP.						HEAT; TREATMENT
	T. S. (PSI)	Y. P. (PSI)	% Elong 2. in.	Red Area %	Brinell	Charpy	
12CrLC	197,000 116,000	139,000 96,000	16 23	42 60	372 230	13 25	H&SR600F N&D1200F
12CrMc	222,000 125,000	160,000 100,000	12 20	34 55	412 237	3 14	H&SR600F N&D1200F
12CrHC	222,000 141,000	168,000 114,000	1 14	1 17	474 267	1 5	H&SR600F N&D1200F
12Cr-Tool Steel					223 653		Annealed Hardened
18Cr	75,000	50,000	10	12	170	2	A1450F—AC
28Cr	75,000	50,000	2	2	196	1	As Cast
28-3	100,000	61,000	13	12	207	2	A1650F—AC
28-3Mo	85,000	56,000	5	6	228	2	A1650F—AC
28-3HC					300		As Cast
18-8S	78,000	38,000	55	60	140	75	2000F—WQ
18-8SCb	85,000	44,000	45	50	150	30	2000F—WQ
18-8SMo	88,000	45,000	50	55	160	70	2000F—WQ
18-8FM	80,000	42,000	45	50	155	75	2000F—WQ
18-8	83,000	42,000	55	60	155	75	2000F—WQ
20-10	80,000	40,000	55	60	155	75	2000F—WQ
8-20	79,000	47,000	23	24	150	80	2000F—WQ
18-8MoCuBe	152,000	122,000	3	2	363		2000F—WQ and hardened at 925 F
20-25Mo	70,000	35,000	20	20	140		2000F—WQ
20-29MoCu	75,000	40,000	45	50	140	15	2000F—WQ
25-12S	82,000	44,000	40	40	165	70	2000F—WQ
25-12SCb	90,000	55,000	25	25	175		2000F—WQ
25-12SMo	95,000	60,000	20	20	185		2000F—WQ
25-12	90,000	45,000	26	27	170	15	As Cast
23-12W	93,000	52,000	32	30	185		1950F—AC
29-9	85,000	45,000	10	13	204	10	As Cast
25-20	75,000	47,000	16	17	175	12	As Cast
15-35	65,000	40,000	8	9	168	4	As Cast
15-65	72,000	40,000	8	10	185	5	As Cast

A—Annealed. AC—Air cooled. WQ—Water quenched.
H & SR—Hardened and stress relieved. N & D—Normalized and drawn.

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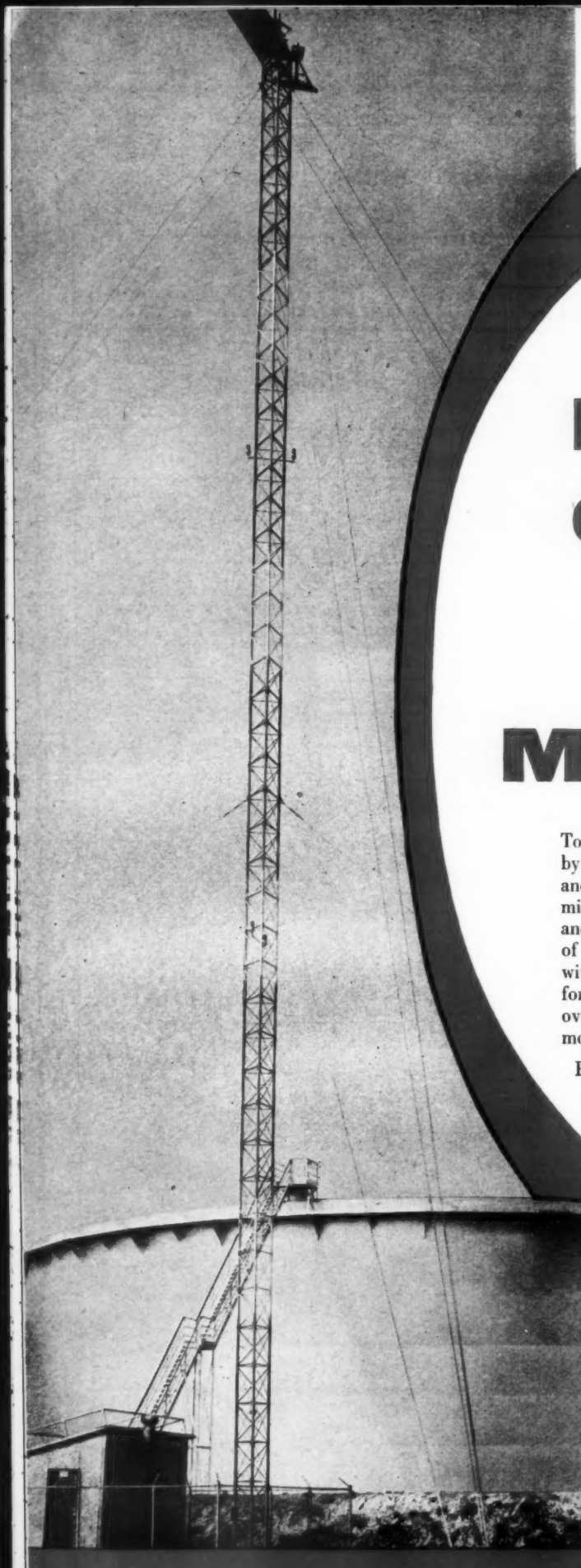

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NATURAL GAS FLOW—CRITICAL VELOCITY, RATIO OF SPECIFIC HEATS, SPECIFIC VOLUME, ETC.

No.	Calculated gross heating value	Gas analysis: Methane CH_4	Ethane C_2H_6	Carbon dioxide CO_2	Nitrogen N_2	Calculated specific gravity based on air = 1.0	Calculated ratio of specific heats, n	Calculated specific vol. at 60° F. & 1 atmos., cu. ft. per lb.	Critical Velocity Factor $\sqrt{gnV}$	Critical velocity, ft. per sec. at various pressures: Pressure, lb. per sq. in., absolute 50	100	150	200	250	300	350	400	450	500
1	700	51.5	10.2	0.0	38.3	0.76	1.321	17.21	27.06	2295	3247	3978	4592	5133	5623	6075	6494	6889	7260
2	960	74.9	11.6	13.0	0.5	0.74	1.280	17.77	27.07	2297	3248	3979	4594	5135	5625	6077	6496	6892	7263
3	970	96.0	0.0	0.8	3.2	0.58	1.307	22.80	30.98	2629	3718	4554	5257	5877	6438	6955	7436	7888	8312
4	989	92.4	3.1	1.4	3.1	0.60	1.298	22.02	30.34	2574	3641	4460	5149	5755	6305	6811	7282	7725	8140
5	990	98.0	0.0	0.7	1.3	0.57	1.300	23.16	31.14	2642	3737	4578	6342	5907	6471	6991	7474	7928	8355
6	1002	91.3	4.5	0.8	3.4	0.60	1.309	21.94	30.41	2580	3649	4470	5161	5769	6319	6827	7298	7742	8159
7	1003	99.2	0.0	0.2	0.6	0.56	1.293	23.48	31.27	2653	3752	4597	5307	5932	6498	7020	7504	7961	8390
8	1012	97.3	0.0	0.4	2.3	0.59	1.300	23.11	31.10	2639	3732	4572	5278	5900	6463	6982	7464	7918	8344
9	1012	92.6	4.3	0.6	2.5	0.59	1.295	22.19	30.42	2581	3650	4472	5162	5771	6321	6829	7300	7745	8162
10	1013	78.3	12.6	0.2	8.9	0.66	1.299	20.05	28.94	2456	3473	4254	4911	5490	6014	6497	6946	7368	7765
11	1016	88.8	6.7	0.8	3.7	0.61	1.293	21.51	29.93	2540	3592	4400	5079	5678	6219	6719	7184	7620	8030
12	1037	66.5	20.7	0.3	12.5	0.71	1.286	18.49	27.67	2348	3320	4067	4696	5249	5750	6212	6640	7045	7424
13	1042	93.1	5.7	0.4	0.8	0.59	1.286	22.27	30.37	2577	3644	4464	5154	5761	6311	6818	7288	7732	8148
14	1048	91.9	6.8	0.0	1.3	0.59	1.292	22.14	30.35	2575	3642	4461	5150	5757	6307	6814	7284	7727	8143
15	1064	83.5	12.5	0.2	3.8	0.63	1.289	20.74	29.34	2489	3521	4313	4979	5566	6097	6587	7042	7470	7872
16	1065	69.4	20.6	0.1	9.9	0.70	1.277	18.84	27.83	2361	3340	4091	4723	5279	5783	6248	6680	7086	7467
17	1068	90.0	9.0	0.2	0.8	0.60	1.362	21.75	30.89	2621	3707	4541	5242	5860	6419	6935	7414	7865	8288
18	1074	75.4	17.7	0.3	6.6	0.67	1.291	19.57	28.52	2420	3422	4192	4840	5410	5926	6403	6844	7261	7652
19	1087	88.0	11.2	0.0	0.8	0.61	1.287	21.44	29.81	2529	3577	4382	5059	5655	6195	6692	7154	7590	7998
20	1093	74.8	19.1	0.3	5.8	0.68	1.288	20.41	29.09	2468	3491	4276	4937	5518	6045	6531	6982	7406	7805
21	1100	82.7	15.1	0.0	2.2	0.63	1.277	20.61	29.11	2470	3493	4279	4940	5522	6049	6535	6986	7409	7810
22	1150	79.8	19.5	0.0	0.7	0.65	1.284	20.13	28.85	2448	3462	4241	4896	5473	5995	6477	6924	7345	7740
23	1175	75.4	23.4	0.0	1.2	0.68	1.274	19.50	28.28	2400	3394	4157	4799	5365	5877	6349	6788	7200	7588
24	1192	73.2	25.6	0.0	1.2	0.69	1.273	19.20	28.06	2381	3367	4125	4762	5323	5831	6299	6734	7144	7528
25	1203	70.0	28.0	1.1	0.9	0.71	1.275	18.62	27.65	2346	3318	4065	4692	5245	5746	6207	6636	7040	7418
26	1251	66.6	32.7	0.0	0.7	0.72	1.265	18.33	27.32	2318	3278	4016	4636	5183	5677	6133	6556	6956	7330
27	1268	59.8	37.6	0.4	2.2	0.75	1.267	17.50	26.72	2267	3206	3928	4534	5069	5552	5999	6412	6803	7169
28	1510	32.3	67.0	0.0	0.7	0.89	1.242	14.88	22.79	1934	2735	3350	3867	4323	4736	5116	5470	5802	6115
29	1510	37.5	59.6	0.0	1.7	0.86	1.241	15.55	24.93	2115	2992	3665	4231	4729	5180	5597	5984	6347	6689

Remarks: (1) Critical velocity in the vena contracta equals the velocity of sound in the gaseous medium considered. Velocity of sound in a gaseous medium may be expressed as follows:

$$v = \sqrt{gnpV}$$

where
- v = velocity of sound, ft. per sec.
- g = acceleration of gravity, ft. per sec. per sec.
- n = ratio of specific heats
- p = absolute pressure, lb. per sq. ft.
- V = specific volume, cu. ft. per lb.

(2) Critical velocity at other pressures than shown may be calculated by multiplying the critical velocity factor (as shown above) by the square root of the pressure expressed in lb. per sq. ft. absolute.

(3) Deviation from Boyles' Law has been disregarded.

Get Into Tight Spots at a Profit ...With a Sherman Power Digger!

Here's real proof of the compactness and maneuverability of the Sherman Power Digger! The job: Dig a 6 foot deep machine foundation hole 10 feet square in a working area only 20 feet square, with overhead beams and lights reducing the ceiling limit to less than 10 feet in some spots.

The floor was 8 to 10 inches of concrete, reinforced with ¼ inch steel rod. It was broken up with air tools, then loaded into a dump truck by the digger. Manual loading would have been difficult because of the reinforcing rods, but these presented no problem when loaded mechanically.

Digging and loading took less than four hours, in spite of the limited maneuvering area. Estimated time for hand labor: Three men working about 2½ days!

If you now excavate by hand, or if your heavier power equipment cannot work in tight spots, you'll profit with a Sherman Power Digger. It's compact, flexible, fast, easy to operate. It costs little to buy, less to maintain, quickly pays for itself. For the whole story, write today for Bulletin No. 513.

Designed, Engineered and Manufactured Jointly by
SHERMAN PRODUCTS, Inc.
Royal Oak, Michigan
WAIN-ROY CORPORATION
Hubbardston, Mass.

Patent No. 2,303,852
Other patents pending
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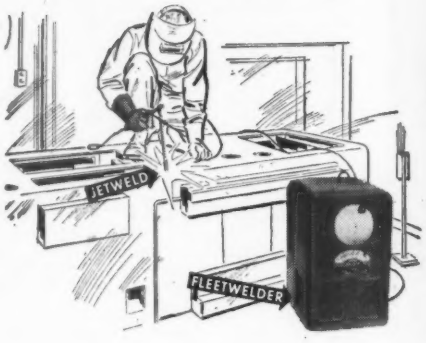
Sherman
PRODUCTS, INC.
ROYAL OAK, MICHIGAN
Sherman SP Products

"JETWELDING"



...greatest team for *low cost, high speed* hand welding

Lowest manual welding costs are achieved with "Jetweld", high speed welding electrode developed and introduced by Lincoln, and "Fleetwelder"—Lincoln's AC transformer-type welder.

For the first time, "Jetweld" utilizes powdered metal in the electrode coating . . . enabling use of higher currents to speed welding 35% and more. Iron powder becomes an additional source of metal for the weld. Welds are more uniform, free of undercut, of X-ray quality . . . require a minimum of skill and effort on the part of the operator.

Average increases in speed are 35% and more.

TYPICAL APPLICATION:

Figure 1. *Down-hand welding of flanges.*

CHECK LINCOLN'S NEW LOW PRICES.
Lincoln's new combination of lower AC machine prices and faster welding with "Jetweld" can cut your welding costs. Have your Lincoln representative check your requirements for electrodes and welders. Call or write.

THE LINCOLN ELECTRIC COMPANY
Dept. 2806, Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

NATURAL GAS FLOW—CRITICAL VELOCITY, RATIO OF SPECIFIC HEATS, SPECIFIC VOLUME, ETC.

No.	Critical Velocity Factor $\sqrt{gnV}$	Critical velocity, ft. per sec. at various pressures Pressure, lb. per sq. in., absolute												
		550	600	650	700	750	800	900	1000	1100	1200	1300*	1400	1500
1	27.06	7,615	7,953	8,278	8,592	8,892	9,184	9,742	10,270	10,770	11,249	11,709	12,150	12,577
2	27.07	7,617	7,956	8,281	8,595	8,895	9,188	9,745	10,270	10,774	11,253	11,713	12,154	12,582
3	30.98	8,718	9,105	9,477	9,836	10,180	10,515	11,153	11,760	12,330	12,878	13,405	13,910	14,400
4	30.34	8,538	8,917	9,281	9,633	9,970	10,297	10,922	11,510	12,075	12,612	13,128	13,623	14,102
5	31.14	8,763	9,152	9,526	9,887	10,233	10,569	11,210	11,820	12,394	12,945	13,474	13,982	14,474
6	30.41	8,557	8,937	9,302	9,655	9,993	10,321	10,948	11,540	12,103	12,641	13,158	13,654	14,135
7	31.27	8,799	9,190	9,565	9,928	10,275	10,613	11,257	11,870	12,445	12,999	13,531	14,040	14,534
8	31.10	8,752	9,140	9,513	9,874	10,219	10,555	11,196	11,800	12,378	12,928	13,457	13,964	14,455
9	30.42	8,560	8,940	9,305	9,658	9,996	10,325	10,951	11,540	12,107	12,646	13,163	13,659	14,139
10	28.94	8,144	8,505	8,853	9,188	9,510	9,822	10,418	10,980	11,518	12,030	12,522	12,994	13,451
11	29.93	8,422	8,796	9,156	9,503	9,885	10,158	10,775	11,360	11,912	12,442	12,951	13,439	13,911
12	27.67	7,786	8,132	8,464	8,785	9,092	9,391	9,961	10,500	11,013	11,502	11,973	12,424	12,861
13	30.37	8,546	8,926	9,290	9,642	9,980	10,308	10,933	11,530	12,087	12,625	13,141	13,636	14,116
14	30.35	8,540	8,920	9,284	9,636	9,973	10,301	10,926	11,520	12,079	12,616	13,132	13,627	14,107
15	29.34	8,256	8,623	8,975	9,315	9,641	9,958	10,562	11,140	11,677	12,197	12,695	13,174	13,637
16	27.83	7,831	8,179	8,513	8,836	9,145	9,446	10,019	10,560	11,076	11,569	12,042	12,496	12,935
17	30.89	8,692	9,079	9,449	9,808	10,150	10,484	11,120	11,720	12,294	12,841	13,366	13,870	14,358
18	28.52	8,026	8,382	8,724	9,055	9,372	9,680	10,267	10,820	11,351	11,856	12,341	12,805	13,256
19	29.81	8,389	8,761	9,119	9,465	9,796	10,118	10,732	11,310	11,864	12,392	12,899	13,385	13,856
20	29.09	8,186	8,550	8,899	9,236	9,559	9,873	10,472	11,040	11,578	12,093	12,587	13,061	13,521
21	29.11	8,192	8,555	8,905	9,242	9,566	9,880	10,480	11,050	11,586	12,101	12,596	13,070	13,530
22	28.85	8,118	8,479	8,825	9,160	9,480	9,792	10,386	10,950	11,482	11,993	12,483	12,954	13,409
23	28.28	7,958	8,311	8,651	8,979	9,293	9,598	10,181	10,730	11,255	11,756	12,237	12,698	13,145
24	28.06	7,896	8,247	8,584	8,909	9,221	9,524	10,102	10,650	11,168	11,665	12,142	12,599	13,042
25	27.65	7,781	8,126	8,458	8,779	9,086	9,384	9,954	10,490	11,005	11,494	11,964	12,415	12,852
26	27.32	7,688	8,029	8,357	8,674	8,977	9,272	9,835	10,370	10,873	11,357	11,821	12,267	12,698
27	26.72	7,519	7,853	8,174	8,484	8,780	9,069	9,619	10,140	10,635	11,108	11,562	11,997	12,419
28	22.79	6,413	6,698	6,971	7,236	7,489	7,735	8,204	8,649	9,070	9,474	9,861	10,233	10,593
29	24.93	7,015	7,327	7,626	7,915	8,192	8,461	8,975	9,461	9,922	10,363	10,787	11,194	11,587

*See Sheet 1, P 681.3 for other data pertaining to these gases.

OIL and GAS TRADE NEWS

Foxboro Builds Factory

A new 15,000 sq ft plant has been constructed at 2270 Noblestown Road, Pittsburgh, Pennsylvania, by The Foxboro Company. The new factory, located a short distance from the new East and West Parkway and the Greater Pittsburgh Airport, will double the present instrument assembly, service, and repair facilities.

Dow Sales Decrease

Sales of The Dow Chemical Company fell one-half of one per cent short of the record high posted last year, the company has reported. Dividends from associated companies and other revenues brought Dow's total income to $436,417,000. In 1953 the company's sales were $430,385,000 and its total income $439,617,000.

New Corporation Formed

The Carson-Wolf Corporation has announced its formation to become constructors for the petroleum, natural gas, and chemical industries, with offices in the Melrose Building, Houston, Texas. Corporation is small enough to guarantee personal supervision of its jobs by one of its officers and big enough to handle any size project. It has available for use, heavy construction equipment with an approximate value of $1,600,000, all less than 2 years old.

Lane-Wells Opens Branch

Lane-Wells Company has opened a branch at 1701 West Fifth Street, Bartlesville, Oklahoma. Robert D. Johnson has been appointed station superintendent there and transferred from Perry.

Rolo Increases Facilities

A 40 per cent increase in plant facilities of Rolo Manufacturing Company has been announced by R. K. (Bob) Franklin, founder and owner of the Houston company. Plant expansion is part of Rolo's planned development program to keep production capacity up with product demand.

Chiksan to Make Mining Gun

Chiksan Company has completed negotiations to take over the manufacture and sale of the Intelligiant hydraulic mining gun from the Intelligiant Corporation. Gun will be manufactured in Chiksan's Brea, California, plant, and will be marketed throughout the world by the Chiksan organization under the trade name of Chiksan Intelli-Giant.

Officers of Kobe, Inc., who recently purchased the Kobe Division of Dresser Equipment Company, are: C. J. Coberly, president; C. James Coberly, Jr., vice president and general manager; and Harry C. Gunetti, vice president for manufacturing.

New Wilson Supply Company store, recently opened at McAllen, Texas. Wilson personnel are: S. G. (Doc) Wyatt, general manager of stores; Wayne H. Harris, district manager; Kinney Hellums, store manager, and Bill Neff, office manager.

Herb J. Hawthorne, Inc., personnel present at a sales meeting held in Billings, Montana on June 25, and 26, 1954, were: Gordon Goodwin, Calgary, Canada; Mrs. Lena Woolf, Edmonton, Canada; Mr. and Mrs. Roy Green, Casper, Wyoming; Mr. and Mrs. Herb J. Hawthorne, Houston, Texas; Mr. and Mrs. R. C. Nelson, Bismarck, North Dakota; and Mr. and Mrs. W. Garceau, Wolf Point, Montana. Standing: Ken Ross, Edmonton, Canada; Gary Gunn; Mr. and Mrs. Al Harding, Calgary, Canada; C. Max Fountain, Denver, Colorado; L. E. Seikmeyer, Denver, Colorado; Earl M. Weaver and P. A. McMurdy, Houston, Texas; Lew Ladwig,, Sidney, Montana; Ray Medlock, Casper, Wyoming; and Charles T. Baker, Sidney, Montana and Oklahoma City.

Johns-Manville Opens Lab

Johns-Manville Corporation has opened, what is said to be, the world's largest laboratory devoted to research and development of asbestos brake linings and other friction materials. The new laboratory, a part of the Johns-Manville Research Center at Manville, New Jersey, houses the largest and most versatile inertia-type dynamometer ever built for testing the stopping qualities of aircraft, railroad, truck, bus and industrial equipment brake materials, according to Dr. R. T. Halstead, manager of Johns-Manville Friction Materials Research.

Scooters Cut Order Waiting

Counter waiting time on orders at The Republic Supply Company of California has been drastically cut again by using electrical scooter transportation for order pickers. Average waiting time for all counter orders, orders placed in person, and telephone orders which are ready to go when the customer calls, has been reduced to five minutes.

Horsepower Race May Begin

The race for horsepower is not confined to the automotive industry. In the next year or two, it may be on again in the machine tool industry — not in the sense of outdoing competitors as in the auto industry — but to keep pace with advanced cemented carbide metalworking developments — developments that may step-up metalworking production at a faster pace, K. R. Beardslee, general manager, Carboloy Department of General Electric, recently stated. He said that new carbide grades under development will demand machines of higher horsepower or perhaps improved design so that the new carbide cutting tools can be used at the higher speeds at which they work with high efficiency.

Norelco to Show Equipment

The Research and Control Instruments division, North American Philips Company, will occupy booths 1122, 1124, and 1126 at the First International Congress and Exposition of the Instrument Society of America, Convention Hall, Philadelphia, Pennsylvania, September 13-24,. Equipment will also be shown at the National Metals Show, International Amphitheatre, Chicago, Illinois, November 1-5.

Fluor Opens Calgary Office

The Fluor Corporation of Canada, Ltd., has opened a Calgary office in the Oil Exchange Building, 309 7th Street West. C. G. Bragg will be resident manager.

St. Paul Moves Facilities

St. Paul Hydraulic Hoist has announced the complete move of its sales and service functions, covering both domestic and export activities, to its new expanded plant site at Mattoon, Illinois. St. Paul transferred its manufacturing operations from Minneapolis, Minnesota, to a modern plant in Mattoon last winter.

Wagner Installs Transformers

Wagner Electric Corporation electrical field service division reports the completed installation of two new Wagner 25,000/33,333 kva, 115,000 Grd. Y to 12470Y/7200 volts, 3 phase, 60 cycle power transformers weighing 112 tons each, by the Memphis Light, Gas and Water Division at its new Adams Street substation in Memphis, Tennessee.

Underwriters Approve Trucks

Underwriters' Laboratories has granted its first approval and listing for a fork-lift truck powered by liquified petroleum gas (LPG) to Clark Equipment Company's Carloader model machine. The LPG-Carloader is a standard model fork truck in 3000-5000 lb capacities, equipped with conventional, Dynatork or Hydratork transmission, factory-modified for LPG operation.

Air Reduction Sales Down

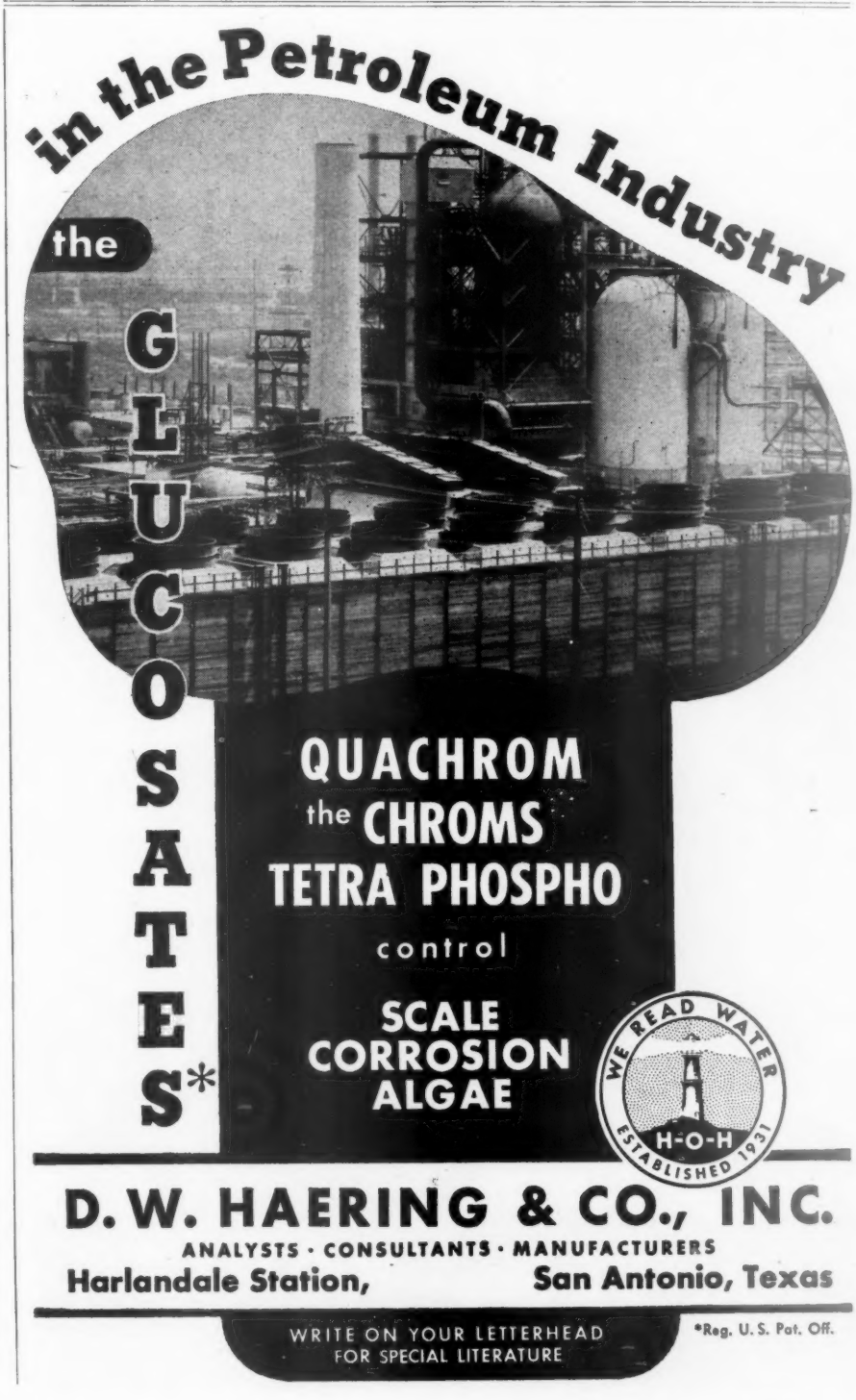
Sales of Air Reduction Company, Incorporated for the first half of 1954 amounted to $59,926,476 as compared with $67,203,365 for the first half of 1953. Net income for the first half of 1954 was $3,219,733. This compares with the 1953 first half net income of $3,798,545.

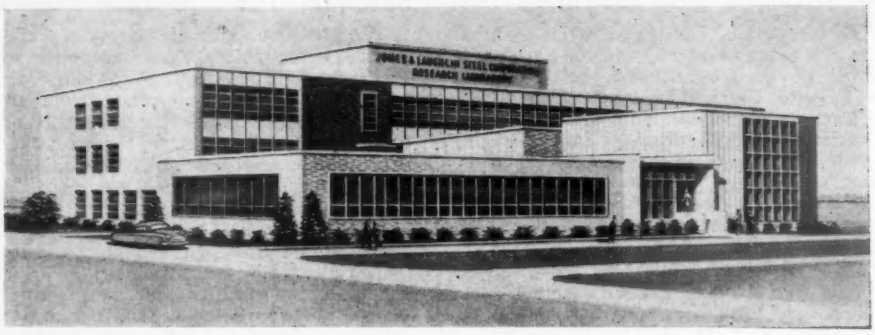
Insul-Matic Gives License

The National Bond Insulators of Bethlehem, Pennsylvania, have accepted an Insul-Mastic Licenseeship to sell and apply the line of reinforced asphaltic coatings marketed by the Insul-Mastic Corporation of America. In the insulation field, these coatings are used as a weather and vapor barrier over insulation.

Sub Uses Tube-Turn Fittings

Piping employed in the atomic submarine Nautilus is fabricated of Type 347 stainless steel, to assure maximum service life under the critical conditions encountered. Flow impediments are minimized, joint leakage eliminated and space saved by making directional changes with TUBE-TURN welding fittings, produced by Tube Turns, Louisville, Kentucky.





Jones and Laughlin's $2,000,000 research center, to be built on Baldwin Hill on Pittsburgh's South Side, overlooking J&H's Pittsburgh Works. The laboratory, to be completed in mid-1955, will consist of several buildings, housing a research staff of 100. Construction on the center is reported to be underway.

KOHLER ENGINES

4-CYCLE
AIR-COOLED

K90

K160

K90 3.6 H.P.
K160 6.6 H.P.
K330 11.8 H.P.
K660 26.8 H.P.

Kohler Engines are engineered and manufactured to the high standards which have made the Kohler mark known for quality the world over.

Power for garden tractors, pumps, sprayers, snow removal equipment, grain elevators, hoists, portable saws, concrete mixers, compressors, industrial lift trucks.

Write for information

K330

K660

Kohler Co., Kohler, Wisconsin
Established 1873

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS
AIR-COOLED ENGINES • PRECISION CONTROLS

Lummus Receives Contract

Air Reduction Company, Inc., has awarded to the Lummus Company the engineering of the recently announced vinyl acetate monomer plant at Calvert City, Kentucky. The plant, which will have a capacity of 30,000,000 lb per year, is scheduled to be in operation early in 1956.

G. E. Forms Departments

General Electric has formed two new General Electric Company organizations, a meter department and an instrument department. Meter department will make its headquarters at Somersworth, New Hampshire, while the instrument department will remain in Lynn, Massachusetts.

Davison Opens Office

Davison Chemical Company Division of W. R. Grace and Company, has opened an office to cover the Southwest and Gulf Coast areas, at 4101 San Jacinto, Houston, Texas.

Atlas Receives Award

Machine gun camera pictures of Atlas Powder Company's Rockmaster blasting system have earned the firm's advertising department an award from the National Industrial Advertising Association. The association made the presentation to Joseph Dannenberg, assistant advertising manager, at its recent convention in Montreal, Canada.

Sperry-Sun Salesmen Meet

The annual Sales Meeting of Sperry-Sun Well Surveying Company was held recently in Houston, Texas, June 10th and 11th, by A. B. Palmer, general sales manager of the company. The meeting was attended by 27 Sperry-Sun salesmen and Samuel H. Williston, vice president of the Company.

Conoflow Appoints Agent

Conoflow Corporation has announced the appointment of The Watts Company of Houston, Texas, as exclusive sales representatives for Cono controls in southeastern Texas and southwest Louisiana. Ralph L. Watts is president of the Watts Company.

U. S. Stoneware Opens Office

The U. S. Stoneware Company has announced the opening of a direct factory sales office in Houston, Texas. Stanley Craig will be in charge of the new offices in Houston.

New Department Created

The mechanical packing division of the Flexrock Company has created a new department for the molding and machining of packing rings and other small parts. Modern equipment has been installed to produce the customary as well as Teflon "V" rings.

Training Section Begun

The Du Pont Company has announced establishment of a new organic chemicals department sales training section under Emory M. Fanning.

Armite Product Approved

An improved anti-seize sealing recently developed by Armite Laboratories of Los Angeles has just received official approval of Underwriters' Laboratories, Inc. The product, designated as Armite Led-Plate No. 250, was particularly developed for the petroleum industry.

C. Lee Cook personnel at a recent sales meeting were: (front row) Arthur Rumsey, Los Angeles, California; W. P. Mayo, Houston, Texas; Joseph C. Buerkle, New York City; Fred D. Durham, president, Louisville, Kentucky; Foster Black, Amarillo, Texas; C. J. Kremer, Jr. ,Chief Engineer, Louisville, Kentucky; and M. A. Boulden, Philadelphia, Pennsylvania. Middle row: Earl Friedrich, R. J. Pohlmann, C. E. Hegewald, Ray Eyl, William Probst, P. W. Mettling, vice president, Louisville, Kentucky, and Joseph Lepic, Chicago, Illinois. Back row: Phillip Kleinhenz, C. D. Duke, Charles Corcoran, Tom Furlong, Walter Rains, John E. Scoggan, assistant sales manager, and B. G. Steitz, Louisville, Kentucky.

Compressor Agent Appointed

Cooper-Bessemer Corporation, and Southwest Industries, Inc., have signed a contract concerning Cooper-Bessemer compressors. Southwest Industries will sell packaged GMXA compressors in the states of Texas, Louisiana, Oklahoma, Arkansas, and New Mexico,and will build the skid bases and handle the erection and assembly of all piping and necessary auxiliary equipment to complete the packaged unit.

Beach Pollution Controlled

A Hydril automatic pump accumulator along with two other pieces of Hydril equipment is helping Monterey Oil Company to keep pollution on California beaches under control while Monterey is drilling its offshore well. Bathing areas of Long Beach and Seal Beach are nearby the test.

Ampco Appoints Distributor

Ampco Metal, Inc., has appointed the Davis Emergency Equipment Company as a Class A Safety Tool distributor.

Davison Wins Safety Award

The Davison Chemical Corporation, new Davison Chemical Company Division of W. R. Grace and Company, won the Award of Honor of the National Safety Council for 1953, repeating successes scored in 1950 and 1951. Award certificate was presented by J. W. Carothers, president of the Baltimore Safety Council.

Crane to Observe Birthday

Crane Company will observe its 100th birthday on July 4, 1955. The Centennial will be celebrated at Crane Company's Chicago general office, plants, branches and subsidiaries during the entire year, with events of national significance.

Clark Appoints New Dealers

Thirteen new dealers have been appointed to sell and service the Michigan line of excavator-cranes and tractor shovels, products of the construction machinery division of Clark Equipment Company. Eight of the dealers will handle both excavator-cranes and tractor shovels. Five of the dealers will handle only Michigan's tractor shovels.

Glass Firm Appoints Counsel

Jack Solon Associates has been retained as public relations counsel for Glass Fibers, Inc., according to an announcement by R. H. Barnard, president of the glass firm. New counsel will handle community and financial-stockholder relations along with corporate publicity.

"SAND-FRAC" PROCESS Gets a Lift with WISCONSIN-POWERED Equipment

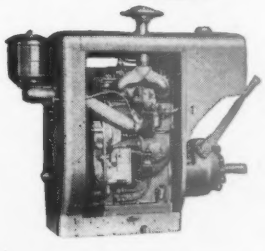
A Model TFD 2-cylinder Wisconsin Heavy-Duty Air-Cooled Engine operates the paddles in the two 500-gal. mixing tanks of this Dowell Twin-Tank Unit which supplies a mixture of sand and oil for use in the rapidly expanding "Sand-Frac" Process.

This Wisconsin-powered unit starts mixing oil and sand from the time the rig leaves the warehouse until the mixture is introduced into the oil formation under high pressure. Some wells that only have a "show" when drilled in, are fractured into flowing wells ...justifying many old areas to be reworked.

This is another typical Oil Field power application for Wisconsin Heavy-Duty Air-Cooled Engines . . . delivering dependable Lugging Power to fit both the job and the machine. Wisconsin Engines are available in a complete power range from 3 to 36 hp., 4-cycle single cylinder, 2- and 4-cylinder models.

Power TO FIT THE JOB

Power TO FIT THE MACHINE



This is the Model TFD 2-cylinder Wisconsin Air-Cooled Engine that supplies dependable power for the Dowell Mixing Tank Unit. Equipped with Stellite exhaust valves and valve seat inserts for long life and minimum servicing.

WISCONSIN MOTOR Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

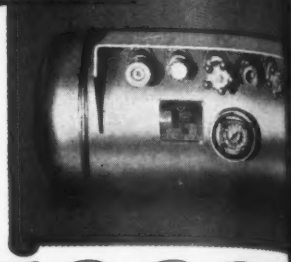
WRITE TO HARLEY SALES CO.
619 SOUTH MAIN STREET • TULSA, OKLAHOMA
3420 McKINNEY AVENUE • HOUSTON, TEXAS
505 SOUTH MAIN STREET • WICHITA, KANSAS
OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

A 8036-½-I

LPG and Gasoline FUEL TANKS

STORAGE TANKS
LPG, Anhydrous Ammonia and Gasoline

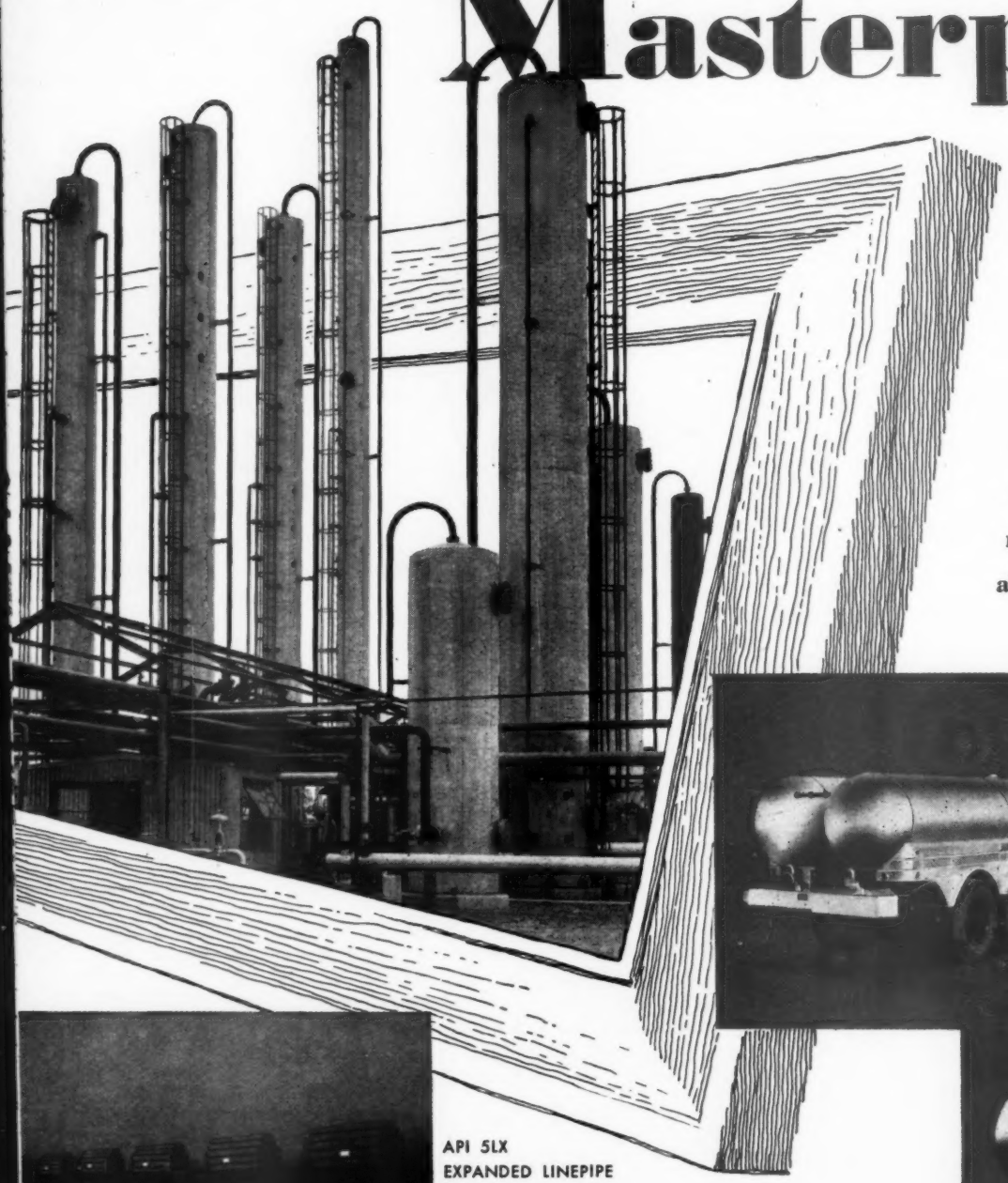
From the Great Southwest...

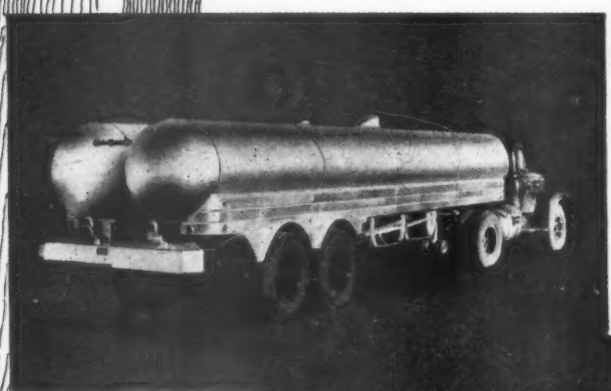


ALL TYPES REFINERY VESSELS

Masterpieces of steel construction

A few examples of production and custom steel fabrication, designed and produced by the facilities of Master Tank & Welding. For any requirements, write, wire or phone. We also warehouse steel plate.

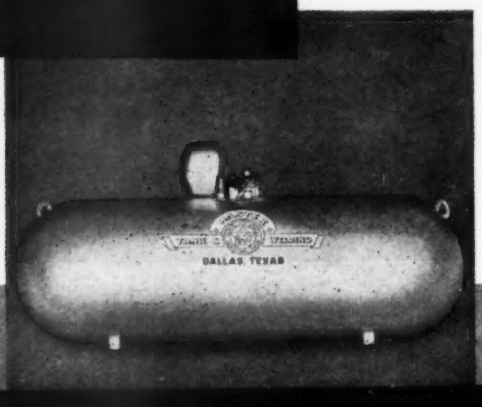




LPG and Anhydrous Ammonia TRANSPORT TANKS

API 5LX
EXPANDED LINEPIPE
20" - 30" Diameter

ANHYDROUS AMMONIA SYSTEMS



LPG
DOMESTIC
SYSTEMS

MASTER TANK & WELDING

P. O. Box 5146 • Dallas, Texas • PRospect 2441

TRADE PERSONALS

Dr. J. E. Taylor has rejoined The Girdler Company. Taylor's major assignment will be the development and application of new catalysts. A graduate of Ohio State University, Taylor left the company in 1944 to be associated with the Manhattan Project at Columbia University. He saw service with three other companies upon leaving the project.

Wililam A. Rock has joined Shultz y Cia. of Mexico City, Mexico, The Foxboro Company's representative in Mexico. Rock will be headquartered in Monterrey and will serve northeastern Mexico, handling instrument applications in this important oil producing section. Rock joined Foxboro in 1945. He has served as industrial engineer in several Foxboro offices and was manager of the Corpus Christi office.

Donald F. Taylor, Jr., formerly manager of the special services department of Otis Pressure Control, Inc., is now Otis' consulting engineer for Oklahoma and West Texas. Taylor has been in Otis' engineering department for almost fifteen years.

John V. Fredd has been appointed project engineer of Otis Engineering Corporation. He was formerly Otis' senior design engineer. Fredd joined Otis in 1947 after seven years with the AC Spark Plug Division of General Motors Corporation.

Godfrey Cajthaml, former field salesman at Williston, North Dakota, was named store manager at Glendive, Montana, for The Continental Supply Company. **B. J. Veach,** who had been store manager in Glendive, became field salesman at Williston. **Wade Farrar, Jr.,** moved from field salesman at Duncan, Oklahoma to store manager at Healdton, Oklahoma, replacing **Doyle H. Cavins,** who became field salesman at Healdton.

F. J. Bradford has been appointed to Grove Regulator Company's Houston, Texas, sales engineering staff. He attended both the University of Kansas and the University of Oklahoma.

Others appointed to the Houston office are: **Eldon E. Hulsey, Paul Nerren, C. B. Wright, Jr.,** and **J. O. Hicks,** who will be assistant division sales manager.

W. J. Hancock has been appointed district manager of a new office opened by Grove in New Orleans, Louisiana. Prior to his transfer to New Orleans, Hancock was assigned to Grove's Corpus Christi office.

James D. Helm has been appointed as sales manager for mobile communication equipment and special accounts for the General Electric Company. He will direct the national sales of G-E two-way radio equipment. Helm joined General Electric in 1943 and held several accounting positions in Schenectady, New York, and Syracuse, and was appointed sales manager of special accounts this year.

Marvin Wall

R. C. Gamble

Marvin Wall has been named district manager of the heavy machinery division and **R. C. "Dick" Gamble** has been appointed sales engineer, Dallas territory for Nordberg Manufacturing Company.

Wall, formerly with the Cooper-Bessemer Corporation, joined Nordberg in 1949. Gamble joined the Nordberg organization in 1948. He is a graduate of Marquette University and the University of Wisconsin.

E. L. Farrell has been appointed district manager for the Milwaukee territory and **Wm. C. Young** as district manager, Great Lakes territory. Farrell and Young are both graduates of Marquette University and following World War II both were appointed as sales engineers with the company.

Martin B. Jaeger has been promoted to publicity manager of Bucyrus-Erie Company. He succeeds **Emory M. Heuston.** When named to his new position, Jaeger was assistant publicity manager, a post he held for three years. He joined the company in 1943.

Carl W. Kalchthaler has been appointed chief engineer for the Hyatt Bearing Division of General Motors Corporation. Kalchthaler has been with Hyatt since 1925. He was graduated from the University of Michigan in that year with a bachelor's degree in mechanical engineering and joined the Hyatt Detroit sales organization as sales engineer.

Keith E. Davis has been elected controller of Black, Sivalls & Bryson, Inc. Joining Black, Sivalls & Bryson in February, 1951, Davis has been assistant controller since that time, and has been acting controller since April, 1954. A graduate of the University of Iowa, Davis had been with Ernst and Ernst before joining the company.

Hugh Kirkpatrick has been appointed manager of the Kilgore, Texas, branch. He has been with BS&B since August, 1953, having previously worked for Cities Service Oil Company. **R. P. "Dick" Morris** has been transferred from Wichita Falls to Gainesville, Texas, as sales representative. He joined BS&B in Fabruary, 1954.

Lavelle E. "Buck" Jones has been apjointed district sales manager for Casper, Wyoming. He was assistant district manager at Alice, Texas. Replacing Jones at Alice is **Harrell Bruner,** was was transferred from Salem, Illinois, Harrell has been with BS&B since January, 1946.

J. L. Heath has been appointed Schlumberger Well Surveying Corporation's northern Rocky Mountain division manager with offices at Casper, Wyoming. Heath succeeds **C. A. Rosenthal,** who has been transferred to Denver as southern Rocky Mountain division manager.

T. A. Morris has been made assistant to the manager of the Rocky Mountain area office at Denver, Colorado. He was formerly division manager in Mississippi. Morris replaces **R. P. Burton** who has been transferred from the Rocky Mountain area to become assistant to the manager of the north Louisiana area. **L. P. Vincent** has been transferred from Wolf Point, Montana, to Midland, Texas, where he is assistant to the manager. **J. L. Hallman,** field engineer at Wolf Point, has been placed in charge of that location.

Spencer H. Mieras has been appointed general manager of Bonny Forge and Tool Works.

William Delaney has been appointed as a sales representative in the Oklahoma City area for Oil Center Tool Company. Delaney is a native of Dublin, Ireland. He came to the United States in 1947. He joined O-C-T as a service man and sales representative in 1951. He worked in the East Texas, North Louisiana, and West Texas areas. He resigned from O-C-T in August, 1953, to form his own business. Delaney returned to the company in his present position July 1.

F. J. Bradford

E. E. Hulsey

Paul Nerren

C. B. Wright, Jr.

J. O. Hicks

W. J. Hancock

Trade Personals

George Beese

J. M. Gray

O. V. Coke

R. D. Fagan

N. F. Harmon

Page Edmunds

George Beese has joined Universal Controls Corporation in the executive capacity of plant manager and in charge of all production and purchasing. A graduate in mechanical engineering from Iowa State College, Beese was formerly assistant to the president of C. A. Dunham Company.

James M. Gray has been appointed assistant vice president of McCullough Tool Company. Gray was associated with the National City Bank in New York City in the credits and new business departments before joining McCullough.

Dan Christopher has been appointed marketing manager for Gray Tool Company. Christopher was formerly with Foster Wheeler Corporation where he was assistant engineering manager. He is a graduate of the University of Illinois.

Robert O. Dehlendorf has been named assistant general sales manager of the Electric Motor Division of A. O. Smith Corporation. Dehlendorf was formerly with Jack & Heintz, Inc.

Otha V. Coke has been appointed district representative at El Dorado, Kansas, for U. S. Steel's Oil Well Supply Division. Coke joined "Oilwell" in 1951 at the Oklahoma City store and was appointed assistant district engineer, machinery equipment sales, at Oklahoma City in 1953. He is a graduate of the University of Oklahoma.

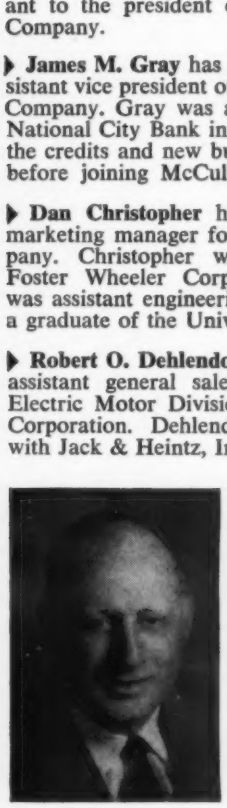
Robert D. Fagan has joined Dowell Incorporated with the title of development engineer. He is a former division manager for Byron-Jackson Incorporated. Fagan worked with the Pacific Cementing Company before joining ICI and BJ. Fagan is a native of Canada.

Willard F. Rockwell, president and board chairman of Rockwell Manufacturing Company, has been elevated to the grade of Fellow in the American Society of Mechanical Engineers at the society's semiannual meeting in Hotel William Penn, Pittsburgh, Pennsylvania. Announcement of the honor was made at a banquet ceremony attended by some 500 people.

Neal F. Harmon has been named General Electric's southwestern regional manager for communication equipment with offices at 3200 Maple Avenue, Dallas, Texas. A graduate of Hendrix College and the University of Arkansas, Harmon joined the General Electric Company in 1930. Previous to his promotion, he was sales manager of two-way radio equipment at Syracuse.

Page Edmunds has been appointed general sales manager of the petroleum catalyst department of Davison Chemical Company Division of W. R. Grace and Company. He succeeds Charles W. Saacke, who has resigned to become president of Commonwealth Oil Refining Company, of Puerto Rico. A graduate of Johns Hopkins University, Edmunds has been with Davison since 1939.

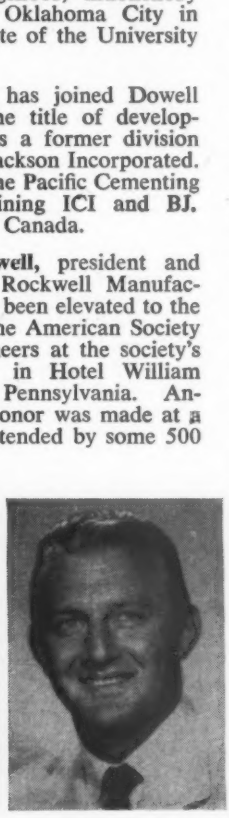
William B. Elliott has been elected chairman of the board of Insley Manufacturing Corporation. **James R. Elliott,** executive vice president, succeeds him as president. **William T. Elliott** has been elected executive vice president.



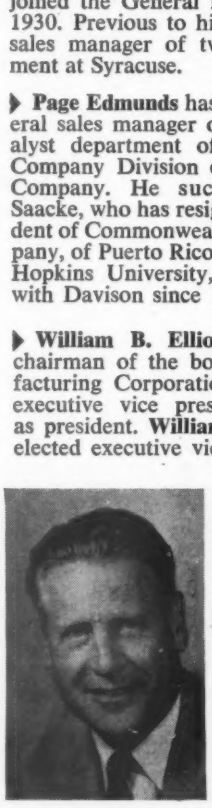
J. L. Cottrell

H. E. Kaye

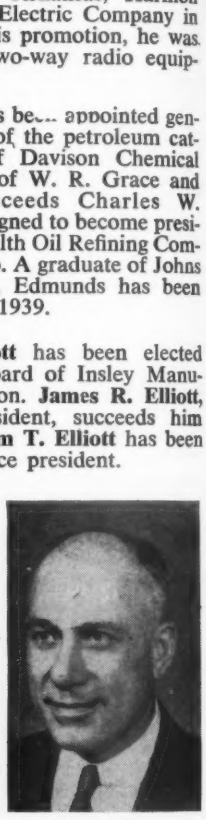
R. S. Yahrmarkt



R. W. Curtis



Ted Affleck



E. B. Hill

J. L. Cottrell, associated with the Rockwell Manufacturing Company for more than 20 years has resigned his position of sales manager of the instrument division to become president of Flow Measurement Company, Incorporated. The new firm will do gas measurement consulting and will be factory representatives for metering and regulating equipment, with offices in the Daniel building in Tulsa, Oklahoma. Cottrell is co-inventor of the McGaughey integrator, is active in the Instrument Society of America, National organization, and is past president of the Tulsa Section. **Al Schawalder** is vice president of the firm.

H. E. Kaye, assistant chief engineer, Rollway Bearing Company, has been named chairman for the next year of the Roller Bearing Engineering Committee, Anti-Friction Bearing Manufacturers Association. His election took place at the annual meeting of the association, May 19-21, at Rye, New York.

R. S. Yahrmarkt, formerly with the Ethyl Corporation of Baton Rouge, Louisiana, has joined The Foxboro Company. He was with the Armour Research Foundation before joining Ethyl. Yahrmarkt is a graduate of Illinois Institute of Technology.

Robert W. Curtis has been named Gulf Coast representative for Cardinal Chemical, Inc. A graduate of Rice Institute, Curtis has recently completed a short course in corrosion inhibition at the Cardinal laboratories at Odessa, where the Nocor series was developed. Curtis is a former intercollegiate tennis champion.

William E. McGuirk, Jr., has been appointed executive vice-president of Davison Chemical Company Division of W. R. Grace and Company. McGuirk, a graduate of the U. S. Naval Academy, was with Kuhn, Loeb and Company, from 1945 to 1953. He became vice-president of W. R. Grace and Company in 1954.

T. "Ted" Affleck, president of Valves Controls, Inc., recently sold his patents and manufacturing rights for his plug valve actuators to Pantex Manufacturing Corporation. In addition as president and owner of Valve Controls, Inc., he will continue to manufacture and distribute Air Brake Valves, High Pressure Cylinders and other lines nationally through distributors.

E. B. Hill, vice-president of Gar Wood Industries has been appointed director of sales, advertising, and export for all corporation products. Hill started with Gar Wood in 1926 and became a vice-president of Gar Wood Industries in 1949.

Charles J. Helmholtz has been named direct factory sales engineer covering the New England States for D. W. Onan and Sons, Inc. He was formerly manager of dealer sales division, Boston branch, Fairbanks-Morse and Company. Helmholtz was with Fairbanks 34 years.

▸ **Richard H. Heilman** has been appointed general traffic manager of the A. O. Smith Corporation to fill the vacancy created by the death of Alfred H. Zastrow. Heilman joined the A. O. Smith traffic department in 1938, and in 1943 became assistant traffic manager.

Warren Hendricksen has been named by A. O. Smith to fill the newly-created post of general sales manager of its Process Equipment Division. He is a 1927 graduate of the U. S. Military Academy at West Point.

▸ **B. P. (Doc) Spann** has been elected vice president of Gardner-Denver Company. Spann, a graduate of the University of Illinois, has been the company's director of personnel the past 8 years and previously was in charge of advertising. **George W. Gutekunst,** formerly district manager for the Gardner Company in Los Angeles, has been transferred to the executive offices in Quincy, Illinois, to assume his new position as general sales manager. Gutekunst joined the sales force in 1937 and in 1947 was transferred to Los Angeles.

▸ **William Irrgang** has been elected president and general manager of The Lincoln Electric Company. **James F. Lincoln** was elected chairman of the board, **John C. Lincoln,** founder of the company, was elected honorary chairman of the board and treasurer. Other officers elected were **John S. Roscoe,** executive vice president; **A. F. Davis,** vice president and secretary; and **George Landis,** vice president.

▸ **W. T. Ireland** has been appointed sales representative for Wolverine Tube, division of Calumet & Hecla, Inc. Ireland, formerly with Bundy Tube Company, will have headquarters in the firm's general sales office in Detroit, Michigan.

▸ **Claude Henley** has been appointed as an account executive with Rives, Dyke, and Company, Houston advertising agency. Henley was formerly assistant advertising manager of Sheffield Steel Corporation. He is a graduate of the University of Missouri.

▸ **Art C. Murphy** has been promoted to general manager of the Frank W. Murphy Company. Murphy joined the company in 1952 as a design engineer, and has worked in both the production and sales departments. He attended the University of Kansas.

▸ **John W. Darr** has been appointed director of public relations and advertising. for ACF Industries, Inc. Formerly in a similar capacity as vice president of Commercial Investment Trusts, Inc., and for many years in public practice, Darr has recently been with the public relations firm of Selvage, Lee and Chase.

▸ **George Saum** has been named manager of Taylor forge aircraft products division. **T. E. Marston** becomes general sales manager of this division, which produces many types of forged and rolled aircraft components.

▸ **Arthur C. Bryan** has been appointed vice president and general manager of Consumer Products and **William H. Feathers,** vice president and general manager of Industrial Products of National Carbon Company, a division of Union Carbide and Carbon Corporation. **Walter A. Steiner** has been appointed vice president in charge of development.

▸ **Peter J. Jensen** has been named manager of manufacturing at Carboloy Department of General Electric Company. Jensen was graduated from the University of Nebraska in 1936 as a mechanical engineer. He joined the Carboloy Department as a tool engineer in 1937, after a year on GE's test course.

▸ **Jack H. Walters,** Houston district sales manager of Rockwell Manufacturing Company's Meter and Valve division since 1951, has been named gas products manager for the entire division. **Thomas I. Stacy,** a sales engineer in the Houston district since 1940, will replace Walters.

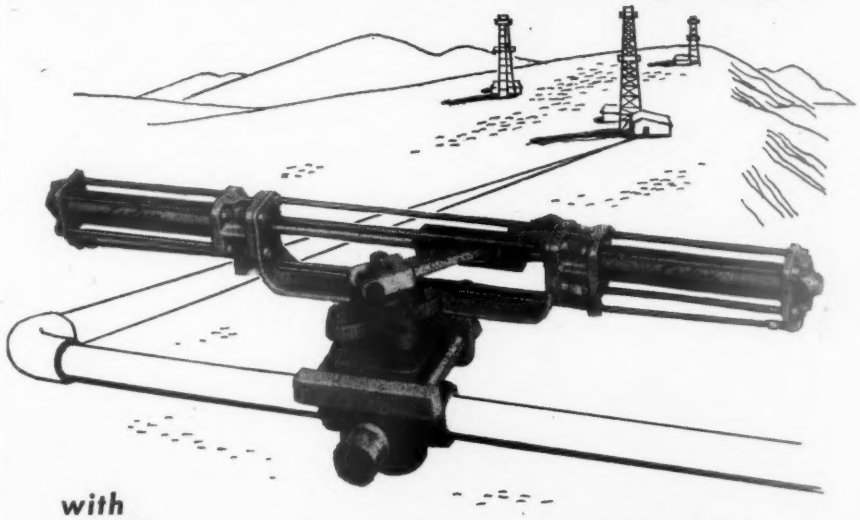
Walters joined Rockwell in 1943 as a sales trainee in the Houston office. Stacy joined Rockwell in 1938 after graduating from Oklahoma A and M College with a B. S. degree in mechanical engineering.

▸ **Alexander E. Walker,** board chairman and director of National Supply Company, has been elected a director of Blaw-Knox Company. Walker is also a director of the Fretz-Moon Tube Company

▸ **Gene Wedereit** has been re-elected chairman of the board of trustees of the National Industrial Advertisers Association's Research Institute. He is director of advertising of The Girdler Company and Tube Turns divisions of the National Cylinder Gas Company. NIAA's headquarters are in Cleveland, Ohio.

▸ **Carl Griffith** has joined McEvoy Company as sales and service engineer in the Ark-La-Tex areas with headquarters in Shreveport, Louisiana. He has worked in the oil industry for the past 15 years in the Gulf Coast and Ark-La-Tex areas.

AUTOMATIC CONTROL of Flow and Gauging



with

Ledeen VALVE ACTUATORS

The Ledeen Tandem Type Actuator, illustrated above, is a pneumatically or hydraulically operated unit for direct or remote control of standard plug valves. It is a package unit and is mounted directly on the valve without need of any special manifolds or outside supports.

★ Direct or Remote Control.
★ Automatic Processing.
★ Safety Installations.
★ Multiple Central Control.
★ Ledeen Valve Actuators are available for operation of Gate, Diaphragm, Plug and other Flow Control Valves.

This tandem actuator, with two cylinders working as a unit, delivers positive, smooth and balanced torque to the valve stem. The balanced design eliminates any cantilever load on the body or eccentric load on the stem.

Because it is a package unit, this actuator can be installed on a valve in any position — easily, quickly, rigidly and without interrupting production. It requires a minimum of maintenance. WRITE FOR BULLETIN 3000.

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VALVE ACTUATORS
AIR HYDRAULIC PUMPS & BOOSTERS

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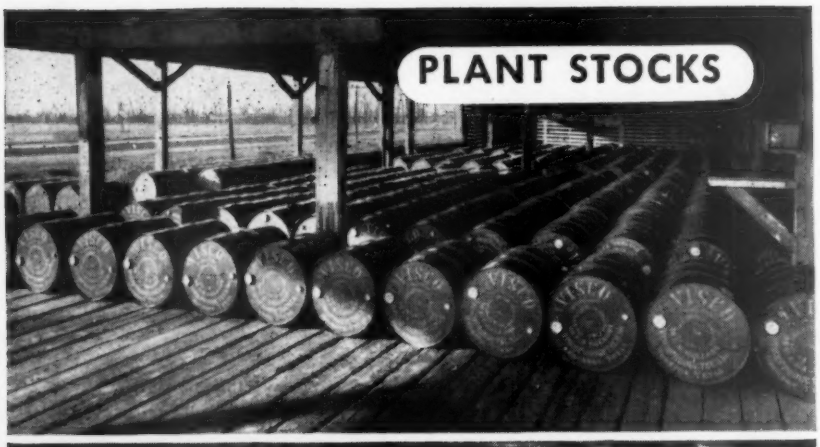

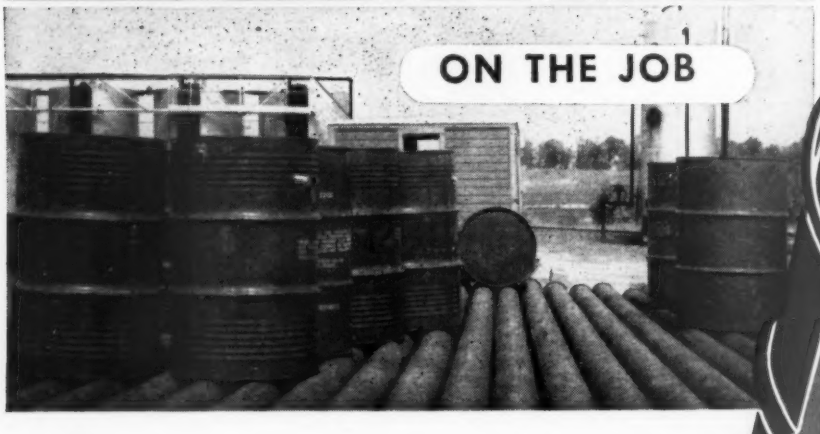

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New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) EVAPORATOR

Roots-Connersville Blower Division of Dresser Industries, Inc., has announced it will market a new type evaporator. The evaporator, identified as SEBAVA, is said to solve the most perplexing single problem encountered in mass evaporation and concentration processes; that of scaling and corrosion on heat transfer surfaces.

Circle letter (A) on reply card.

(B) SPARK PLUGS

U. S. Igniter Corporation has presented three new designs of igniters and spark plugs for industrial and commercial oil and gas burners. It is claimed these plugs eliminate the difficulties experienced by conventional designs and by center and ground electrodes.

Circle letter (B) on reply card.

(C) TRAILER

The Terratrac trailer, as developed by the American Tractor Corporation, can be easily handled by a half ton pick-up truck. Tractor rides low, only 14 in. from the ground. It is equipped with heavy-duty 10 ply tires, electric brakes, a strong sturdy drop-axle, safety chains, and a ball type hitch.

Circle letter (C) on reply card.

(D) LUBER-FINER UNITS

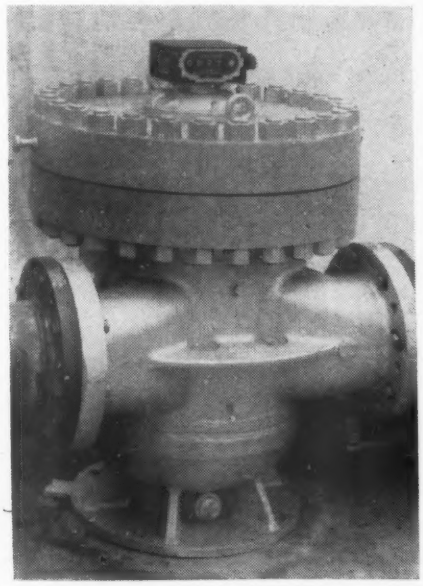
Luber-finer, Inc., has announced two new Luber-finer units, Models 500-C and 750-C. The new models provide simplified,

faster pack replacement by use of an ingeniously designed clamping ring utilizing a single-bolt closure. An important feature is the positive-sealing "O" ring type gasket which assures leak-proof lid closure at all operating pressures.

Circle letter (D) on reply card.

(E) METER

The new Model M-200 meter added to the line of the meter division of A. O. Smith Corporation is described as the



largest meter in the industry. Meter has a rated capacity of 2000 gpm under a working pressure of 1200 psi and weighs 6275 pounds. Principal use of unit will be on high pressure product and crude oil lines.

Circle letter (E) on reply card.

(F) MAGNETS

The Electric Controller and Manufacturing Company has announced the availability of a line of small electro-magnets to be used with mobile materials handling systems. EC&M electro-magnets are furnished in sizes ranging from 12½ to 36 in. in diameter and weighing from 155 to 1900 lb.

Circle letter (F) on reply card.

(G) ELECTRODE

A new shielded arc electrode, the Mir-O-Col 4T, developed specially for build-up of worn tractor rails and grousers is now being marketed by the Mir-O-Col Alloy Company. Mir-O-Col 4T is currently available in a full range of sizes including 1/8, 5/32, 3/16, and 1/4-in.

Circle letter (G) on reply card.

(H) CONVECTOR

The Wall Line Convector, designed specifically for modern institutional and industrial buildings with bands of windows, has been developed by The Trane Company. Convectors are available in 14, 20, and 26-in. heights and in lengths ranging from 2 to 6 ft in increments of 4 in. Cabinet depths are 4 and 6 in.

Circle letter (H) on reply card.

(I) DRILLING RIG

The Jet 43 is 1 of 7 completely new drilling rigs that have been announced by Franks Manufacturing Corporation for drilling up to 7500 ft. The Jet 43 consists of a skid-mounted single drum rotary drilling rig. It is designed for drilling from 4500 to 6000 ft.

Circle letter (I) on reply card.

(J) GASOLINE ENGINE

A new lightweight (140 lb) 21 hp (maximum at 3600 rpm) engine, first of its type and size to be manufactured to Military Standard Parts Specifications, is announced by D. W. Onan and Sons. The 2-cylinder, 4-cycle, air-cooled, gasoline-powered engine is constructed of aluminum.

Circle letter (J) on reply card.

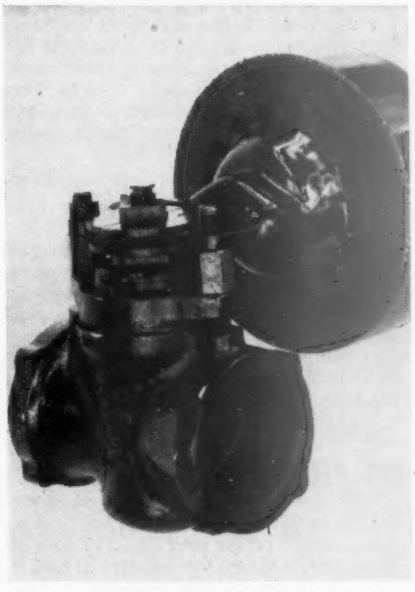
(K) FILTERS

Marvel Engineering Company have recently adapted all models of their sump and line type filters for use in the filtration of all types non-flammable hydraulic fluids. Production of these filters is now on full schedule and shipments can be made immediately if desired. They are available for either sump or line installation in capacities from 5 to 100 gpm.

Circle letter (K) on reply card.

(L) VALVE OPERATOR

The Bettis Plug Valve Operator is a gas actuated attachment for remote control operation of plug valves. Valves from



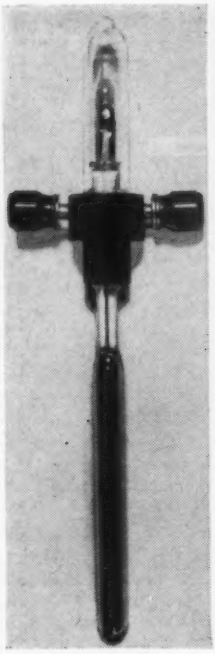
1 to 4 in. can be readily opened and closed on gas pressure of 15 to 100 lb. Operators are friction free, having no pistons or packing glands, and will fail safe on loss of control pressure.

Circle letter (L) on reply card.

(M) THERMOREGULATOR

Philadelphia Scientific Glass Company has introduced a new regulator to the market. The Thermoregulator is said to give room temperature from 550 F with a sensitivity of .02 F in a split second. Added features are: Seventy-five pounds hydrogen pressure that prevents sparking; new design platinum contact point; special capillary tube that allows rising mercury to contact platinum point, and triple vacuum distilled mercury reservoir.

Circle letter (M) on reply card.



Regulator

Gage

(N) TANK GAGE

The Liquidivision Gauge and Control Corporation has announced the development of a tank gage known as Magnalux. Magnalux consists of a non-magnetic column that is connected to the liquid and vapor space of the tank. Within this column a float is free to rise and fall. The float, which has a magnet connected to it, follows change in level and the field from the magnet positions a roller on the outside of the non-magnetic column. Gage can be furnished with switches to actuate audible or visible alarms or to control pumps or valves.

Circle letter (N) on reply card.

(O) OIL WELL METER

A new oil well meter has been developed by Rolo Manufacturing Company. Meter is said to be simple, accurate, and eliminates expensive maintenance problems caused by sand, gas, and other foreign matter in crude oil. It is reported the Rolocheck Model No. 1-24 will handle as much as 1440 bbl per day at 12 lb.

Circle letter (O) on reply card.

(P) DIESEL UNIT

The new UD-1091 Diesel power unit, largest in International Harvester's seven model diesel power unit line, is being displayed throughout the country. The UD-1091 replaces the UD-24 International diesel power unit. Engine produces 203 intermittent horsepower or 162.4 hp at 1400 rpm. As a power unit, the UD-1091 produces 190 intermittent horsepower or 152 continuous horsepower at 1400 rpm.

Circle letter (P) on reply card.

(Q) PUMPS

A new series of production-built centrifugal pumps adaptable to almost any special customer requirements has recently been anounced by Ampco Metal, Inc. These new 1750 rpm single-suction pumps are available in sizes ranging from fractional flow to 600 gpm. Units are available constructed from Ampco alloys or nickel chrome alloys.

Circle letter (Q) on reply card.

(R) FIRE FIGHTING DEVICE

American-LaFrance-Foamite Corporation offers a new device in the "American-LaFrance Proportioner." Proportioner is a dual purpose fire fighting aid because it can be used for drafting 6 per cent Foamite Airfoam (or 3 per cent by use of an adapter) and also Wetter Water. It is said to be simple to use, fast operating, and is materially beneficial in fighting gasoline, oil and grease fires.

Circle letter (R) on reply card.

(S) SPEED REDUCERS

A new line of large industrial speed reducers for application in heavy industry is available from the Westinghouse Electric Corporation. Line consists of a series of single- (Type WSH) and double-reduction (Type WDH) units. Thirteen standard ratios from 2.24 to 9.21 are available for WSH; 16 ratios from 11.3 to 70 are available for WDH.

Circle letter (S) on reply card.

(T) TORQUE COMBINATIONS

Torque converter-engine combinations are now available as optional equipment on certain models of Bucyrus-Erie excavators. The torque converter-engine combinations provide maximum (stalling) torques from 200 to 225 per cent of full load torques of straight friction drive for a given excavator.

Circle letter (T) on reply card.

(U) BELLOWS

Chemically inert, corrosion and heat resistant bellows made from DuPont Teflon by Crane Packing Company, are now available with companion flanges conforming to American Standard bolt hole circles and numbers of pressure up to 125 psi. They can be supplied to fit any pipe size from ½ through 12 in. Operating temperature range is from —94 to +500 F.

Circle letter (U) on reply card.

(V) DRILL RIGS

A new line of portable drill rigs have been introduced by Drilling Accessory Manufacturing Company. The new rigs are designed for fast Seismograph shot hole, blast hole, and water well or core drilling with only minor adjustments required for each operation. The portable rigs are in 2 sizes and have been designated AR-1250 and AR-2000.

Circle letter (V) on reply card.

(W) MARKERS, SIGNS

North Shore Nameplate Inc., has announced the addition of over 7500 new stock items used for pipe markers, container signs, chemical industry and maintenance and repair operations. Standard card size is 2¼-in. by 9-in. and furnished in various colors. Identification tapes require no moistening, easily applied to round as well as flat surfaces, no effect from cold, humidity or vibration.

Circle letter (W) on reply card.

(X) VALVES

Longer-wearing wedges, stronger stem-to-wedge connections and a union bonnet said to give increased efficiency are incorporated into newly designed forged steel gate valves announced by The Ohio Injector Company. Wedges are made of 13 per cent chrome stainless steel for corrosion resistance.

Circle letter (X) on reply card.

(Y) COMPRESSOR

Le Roi Company has put the 105 cfm Utility compressor back into the Le Roi Airmaster line. The new Utility has several improved features including better air cleaning and cooling through the use of oil bath air cleaners and a pressurized cooling system. Overall width of the unit is only 25 in. and the overall length is 82 in.

Circle letter (Y) on reply card.

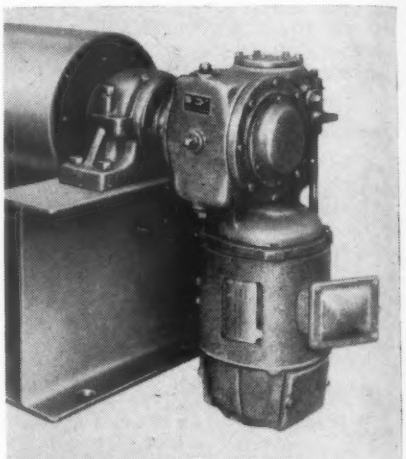
(Z) VISCOSIMETER

Automatic viscosity process control under any condition for any substance made simple and economical by the new Drage viscosimeter. A unique design makes it possible to record and regulate viscosity while taking measurements in an open or closed vessel (under extremes of pressure, temperature or viscosity), in a flow through, in a by pass or in a pipe line.

Circle letter (Z) on reply card.

(AA) FLOATING GEARMOTOR

The Philadelphia Floating Gearmotor was developed by Philadelphia Gear Works in response to the long felt need for a roll or conveyor drive which would



be entirely self-contained and be located at the point where the power was required. The Gearmotor can be mounted in almost any location or position due to its compact design. Gearing is proportioned for 300 per cent peak loading over normal ratings. Housing construction is cast steel or cast iron as required.

Circle letter (AA) on reply card.

(AB) VANE-TYPE HEATER

A new vane-type Calrod heater for air and surface heating has been announced by the General Electric Company's industrial heating department. Heater is designed for a multitude of applications including pipe, platen, valve and pump, process machinery, compound tanks, and machine surface heating. It is available in lengths from 20 to 100 in., 500 to 2500 w, for either 115 or 230 v.

Circle letter (AB) on reply card.

(AC) BEARING HANGER

A two-speed bearing hanger designed to increase the versatility of power take-offs for truck mounted special equipment has been announced by Gar Wood Industries, Wayne division. The bearing hanger is constructed with hardened steel, shaved gears, which run in oil and rotate on ball bearings. Dimensions of the bearing hanger are 12 by 9 1/16 by 7 1/16 in.

Circle letter (AC) on reply card.

(AD) PRESSURE BALANCE

Fast, accurate, non-manual measurement of precision pressures is said to be accomplished by the new precision pressure balance recently released by Consolidated Engineering Corporation. The instrument, Type 37-103, is designed so that readings may be held when required or attached to electrical tabulating devices through a built-in electrical analog DC output of 10 v.

Circle letter (AD) on reply card.

(AE) CRANE CARRIER

A low cost, 6 ft by 6 ft Crane Carrier has been announced by the Schield Bantam Company. The Bantam "200" Carrier features completely new GMC 6-cylinder engine, new radiator, new one-man cab, new brake system, new instruments, new steering gears and a host of other new assemblies, plus reinforced main frame, and completely rebuilt secondary assemblies.

Circle letter (AE) on reply card.

(AF) GLOW PLUGS

All-weather direct electric starting with newly-developed glow plugs have been made available for the Caterpillar D4 track-type tractor. Incorporated into the system are glow plug attachments that provide positive starting in below freezing weather. They prevent battery life from being drained away through prolonged cranking during cold winter months.

Circle letter (AF) on reply card.

(AG) GAS ENGINE

Addition of a new one cylinder gas engine to its Power Chief series of small diesel prime movers has been announced by Nordberg Manufacturing Company. Engine is rated at from 9 to 18 maximum brake horsepower within an operating speed range of 800 to 1800 rpm.

Circle letter (AG) on reply card.

(AH) SPECTROMETER

"One of the most significant advances in the 35-year history of mass spectrometry!" is said of the cycloidal-focusing mass spectrometer recently introduced by Consolidated Engineering Corporation. The new Model 21-620 mass spectrometer provides sensitivity, accuracy, and a higher mass range than previously known in a light, compact, and easily transportable mass spectrometer.

Circle letter (AH) on reply card.

(AI) RADIATOR CORE

The Young Radiator Company has introduced a plate type fin and round tube core, made up of 7 fins per inch that is said to provide 58 per cent more extended surface and 7 times more heat transfer surface than circular fin cores provide with edge contact. Cores are available in copper, brass, admiralty, aluminum or steel tubes, and copper or aluminum fins for every type of service.

Circle letter (AI) on reply card.

Pump manufacturer *standardizes* on LATTICE BRAID* Packing for *all* centrifugal pump models

*Registered Trademark. *Only* Garlock makes LATTICE BRAID rod and shaft packings.

Peerless Pump Division, Food Machinery and Chemical Corporation, Los Angeles, manufactures an entire line of centrifugal pumps. Before changing to LATTICE BRAID, Peerless regularly received frequent complaints on packing from their customers. Now that Peerless has *standardized* on LATTICE BRAID, complaints are rare. In addition, Peerless reports that LATTICE BRAID *resists* the excessive gland pressure often applied by uninformed repairmen. The result is that there is *less* packing and sleeve wear.

Put Garlock LATTICE BRAID Packing to work for your company. All the braided strands of this unique packing are lattice linked together into one structural unit. The strands hold together even when the packing is worn far beyond the limits of wear of ordinary braided packings.

LATTICE BRAID is made from flax, cotton, asbestos, wire-inserted asbestos, Teflon, and asbestos with Teflon impregnation—for various types of services.

Get all the facts about LATTICE BRAID *Packings. Contact your Garlock representative or write for new folder AD-131.*

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Cleveland Denver • Detroit • Houston • Los Angeles • New Orleans • New York City • Palmyra (N. Y.) • Philadelphia Pittsburgh • Portland (Oregon) • Salt Lake City • San Francisco • St. Louis • Seattle • Spokane • Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

GARLOCK LATTICE BRAID PACKING

Trade Literature

Publication will be sent free.

(AJ) TRENCHMOBILE

A new 2-color, 8-page catalog describing dozens of applications for the improved Parsons 88 Trenchmobile has been released by the maufacturer, Parsons Company. The new catalog is illustrated with many photos showing the Trenchmobile, operating parts, and job performance.

Circle letter (AJ) on reply card.

(AK) GAS MEASUREMENT

A highly accurate and reliable instrument and sampling system for continuous measurement of a high purity gas stream is illustrated and described in a new bulletin titled "Measuring High Purity Gases" issued by Arnold O. Beckman, Inc. Bulletin AD-613 contains illustrations of the instrument and a typical sampling system is presented in schematic form.

Circle letter (AK) on reply card.

(AL) SILICONE INSULATION

"Uprating Horsepower With Silicone Insulation" is the subject of a folder released by Dow Corning Corporation. Tables and charts showing performance data are included in the folder.

Circle letter (AL) on reply card.

(AM) ELECTRODES

Bulletin No. WE-166, a stainless steel welding electrode catalog has been issued by the welding products division of the A. O. Smith Corporation. The 24-page booklet covers in detail the metallurgy of stainless steels, provides an A. O. Smith electrode selector table and offers other valuable tabular material on welding processes.

Circle letter (AM) on reply card.

(AN) OIL RIG MOVING

Quick and economical rig moving is the topic of a new booklet titled Oil Rig Moving published by Caterpillar Tractor Company. Booklet shows motor graders and track-type, diesel powered tractors operating on drilling sites in Kansas, Texas, Mississippi, and Montana. Also included are testimonials by equipment owners.

Circle letter (AN) on reply card.

(AO) NEEDLE VALVES

Design details and operating characteristics of its complete line of needle type valves are explained by The Foxboro Company in a new 8-page bulletin, 5C-13. Reference material includes a table of nominal needle sizes with corresponding valve coefficients, and a characteristic curve showing the per cent of maximum flow in relation to the per cent of total lift.

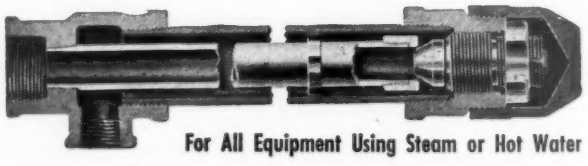
Circle letter (AO) on reply card.

For Temperature Control

$35 Nicholson Trap Replaces $200 Unit

Again demonstrating their remarkable effectiveness as a low-cost temperature control, a large processor reports Nicholson expansion steam traps, at about $35 each, are being installed on outdoor tanks and stills in place of temperature controls. These were costing $110.00 to $200.00, with cost of trap added.

The Nicholson traps are readily adjusted to pass condensate at any temperature below 212° F. No air binding. Lengths, 9" to 40". Easily installed, usually without supports. Pressure, 0 to 250 lbs.



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Heaters	Radiators	Storage Tanks

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W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS

(AP) CRANE

The new 15-B Transit Crane — mobile crane-excavator with 15-ton rated lifting capacity — is now offered by Bucyrus-Erie Company. Crane is designed to handle fast and efficiently the many types of work now considered too small for profitable large machine operation.

Circle letter (AP) on reply card.

(AQ) DIATOMITE PRODUCTS

"Celite Flatting Agents and Pigment Extenders" is the title of a new 16-page, illustrated brochure just issued by Johns-Manville. Brochure covers the general advantages of Celite diatomite products and contains pertinent information on Celite as a filter aid for clarification filtration in producing varnishes, lacquers and so forth.

Circle letter (AQ) on reply card.

(AR) SWITCHES

A newly published catalog 101, entitled "Switches for Industry" has been announced by Micro Switch, a division of Minneapolis-Honeywell Regulator Company. The 20-page illustrated catalog covers twenty-two "families" of switches, describing 258 different switches, actuators and enclosures.

Circle letter (AR) on reply card.

(AS) POWER SLIPS

A 4-page folder on balanced power slips has been published by Web Wilson. Folder contains an illustration showing the slips in operation; other photographs show position of slips when not in use. Detailed information on the slips is included in the folder.

Circle letter (AS) on reply card.

(AT) STEEL CASTING

Lebanon Steel Foundry has announced publication of a new, 32-page brochure on steel casting manufacture. The brochure has an 8½ by 11-in. page size, is lithographed in two colors, and treats the entire process of steel casting manufacture from the design and engineering phase to final applications.

Circle letter (AT) on reply card.

(AU) ALUMINUM JACKETING

Childers Manufacturing Company has published a new folder containing complete application instructions for Childers Jacketing for weather-proofing of insulated lines, towers, vessels, and tanks. Illustrated with detailed drawings, the folder explains how Childers Jacketing is applied on insulated lines including ells, tees, and bends.

Circle letter (AU) on reply card.

(AV) WELDING

Air Reduction is offering a new 12-page reprint entitled, "Carbon-Steel Electrodes for Use with Inert Gas Shields." Booklet is a study of the properties of electrode weld deposits, for production use in the welding of carbon steel by the inert-gas-shielded metal-arc process. Pictures of weld specimens and numerous charts are included in the booklet.

Circle letter (AV) on reply card.

(AW) SEPARATOR

The Petreco division of Petrolite Corporation has announced publication of an illustrated booklet of the new Petreco electric sediment separator. Booklet describes the sediment separating equipment, and gives details on its operation.

Circle letter (AW) on reply card.

(AX) NICKEL ALLOY STEELS

The International Nickel Company, Inc., has issued bulletin A-68 covering the tensile and impact properties of quenched and tempered nickel alloy steels in different sizes. The 36-page bulletin contains over 70 mechanical property charts that show the properties of the steels.

Circle letter (AX) on reply card.

(AY) CRANES AND SHOVELS

A 12-page 2-color catalog illustrating and describing the Lorain "42 Series" has just been released by the Thew Shovel Company. A section is devoted to each of the Moto-Shovel, Moto-Hoe, Moto-Clamshell, and Moto-Dragline with another section giving special emphasis to the crane boom and its equipment.

Circle letter (AY) on reply card.

(AZ) FILM

Bucyrus-Erie Company has released a 2-color pamphlet describing, illustrating, and announcing the availability of a 16 mm sound-color motion picture, "These Users' Views." Folder contains sample of shots in movie and gives information as to obtaining the film.

Circle letter (AZ) on reply card.

(BA) MOTORS

Design of Allis-Chalmers two-pole motors 900 hp and larger is described in a new 8-page bulletin released by the company. Diagrams in the bulletin include a sectioned view of a typical large Allis-Chalmers two-pole squirrel-cage induction motor, and another showing how the machine is spirally ventilated.

Circle letter (BA) on reply card.

(BB) HAND TORCHES

Air Reduction is offering a new 36-page catalog covering their complete line of torches and tips for oxyacetylene cutting and welding. Every Airco standard torch and tip is listed along with the necessary mixers, extensions, adapters, and accessories. Complete information is presented through illustrations, charts, and descriptions.

Circle letter (BB) on reply card.

(BC) SAMPLER

Claremont Instrument Company, Inc., has published a 4-page folder on a sampling device. Description of the instrument along with methods of installation and maintenance is contained in the folder. A cut out drawing showing sampling procedure is also in the folder.

Circle letter (BC) on reply card.

(BD) SPROCKETS

A new 8-page catalog (C56-54) describing the newly expanded line of Morse Taper-Lock stock sprockets is now available from Morse Chain Company. Sizes and prices are given for pitch Type B stock Taper-Lock sprockets and pitch Type C stock Taper-Lock sprockets.

Circle letter (BD) on reply card.

(BE) LIQUID TRANSMITTER

Minneapolis-Honeywell Regulator Company has published a bulletin describing the new Brown Differential Converter transmitter specifically designed to measure liquid level in closed tanks. Bulletin 2291 covers specifications and contains a cut away view of the transmitter.

Circle letter (BE) on reply card.

(BF) GRAVITY METER

The lightweight Worden Gravity Meter is fully described in a new bulletin, GM-201, issued by Houston Technical Laboratories, a subsidiary of Texas Instruments Incorporated.

Circle letter (BF) on reply card.

(BG) HEATERS

American Blower Corporation has released bulletin 7517, covering the latest design of American Blower Venturafin Unit Heaters for steam or hot water applications. Features of design, general engineering data, capacity tables, and piping diagrams, are contained in the bulletin.

Circle letter (BG) on reply card.

(BH) CASING SCRAPER

Bowen Company of Texas has released literature covering a hydraulically operated casing scraper with a unique method of actuation and which is designed so that the scraper blades assure complete coverage of the casing interior.

Circle letter (BH) on reply card.

(BI) STEEL VALVES

A "Technical Tips" booklet describing and illustrating data gathered by the Edward laboratories on valve material, installation, and usage has been published by Edward Valves, Inc. Subjects discussed include "What Heat Does to Valve Trim Hardness," "What Thermal Expansion Does to Valve Materials," "Use of Globe Valves for Throttling Service," "High Temperature Lubricants for Valve Studs and Bushings," and " 'Creep' Robs Metal Strength at High Temperatures."

Circle letter (BI) on reply card.

(BJ) OILFIELD EQUIPMENT

A new 64-page catalog published by IDECO describes the company's complete line of oilfield drilling, workover, and servicing equipment. It is liberally illustrated with full-color drawings, detailed specifications and photographs of IDECO Hydrair Hoists, power rigs, unitized mobile Rambler rigs and matching auxiliary equipment, including rotary tables, swivels and blocks. Company has also released a 8-page, 3-color bulletin on its complete line of Shorty Blocks. Bulletin is illustrated with photographs.

Circle letter (BJ) on reply card.

(BK) AIR COMPRESSORS

Locating troubles in Vertical Water-Cooled Air Compressors is subject of new "Trouble Savers" self-mailer now being offered by Worthington Corporation. Graphically illustrated, mailer explains reasons for such operating troubles as failure to deliver air; insufficient capacity; insufficient pressure; vibration; overheating; overloading motor; knocks; low or high intercooler pressure.

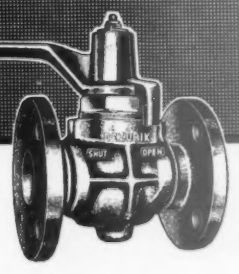
Circle letter (BK) on reply card.

(BL) CORROSION

A lively, 8-page booklet entitled "How to Combat Corrosion" is now available to corrosion engineers and other interested persons from Pipe Line Anode Corporation. The well-illustrated guide shows how to order and how to install magnesium anodes for all types of applications, including tank bottoms, well casings, heater treaters, offshore drilling platforms, flow lines, receiving tanks, and small craft.

Circle letter (BL) on reply card.

LONG-LASTING, TROUBLE-FREE
DEZURIK VALVES....



THE VERSATILE VALVES IN THE
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Wherever lines are valved . . . on liquid flow or vacuum . . . you'll find DeZurik Easy-Operating Plug Valves will do a superior job. . . .

On gasoline and diesel fuel loading racks; on bleeder lines running from pumping wells; on water treater tanks; on suction lines to waterflood pumps; on rotary drilling mud, clay base and oil base; on crude oil tank battery lines; on suction to high pressure oil well cementing pump trucks; on vacuum trucks . . . on all these and many other petroleum applications, DeZurik Valves are proving their versatility and dependability.

In a full range of sizes, metals and models, operated manually, remotely or automatically, with threaded, flanged or victaulic ends. *Write for details.*

DEZURIK SHOWER CO. SARTELL, MINN.

Trade Literature

(BM) DRILLING RIG

National Supply Company has published bulletin No. 420 giving information on its type 50-A consolidated rig. The attractive 15-page bulletin contains drawings and photographs illustrating the parts of the rig.

Circle letter (BM) on reply card.

(BN) ELECTRIC PLANTS

How Onan electric plants are used as emergency standby units, for contractors' portable power needs, as magnet chargers for cranes and trucks, and for primary power for a display coach is told in volume 10, No. 3 of Power Points Digest, a publication of D. W. Onan and Sons, Inc. Many installations are described in the 2-color, pocket sized, 16-page booklet. Prominently featured are several 230-v, direct current Onan electric plants used as chargers for scrap metal companies.

Circle letter (BN) on reply card.

(BO) WELDERS

The Lincoln Electric Company has published an 8-page bulletin on its Lincoln shield-arc engine-driven welders. Different types of welders are pictured in the bulletin along with photographs of the welders in action.

Circle letter (BO) on reply card.

(BP) EQUIPMENT CATALOGS

Black, Sivalls and Bryson, Inc., has announced the publication of three new catalog sections on equipment for field production of oil and gas. Catalog 30-09 describes the BS&B Low Pressure Horizontal Separator, Model H. Catalog 32-01 includes two types of BS&B Junior Indirect Heaters for handling small gas volumes up to 85,000 Btu per hr. Catalog 31-12 covers the BS&B Low Pressure Horizontal Free Water Knockout, Model HLK. Catalogs include complete descriptions of the equipment — applications, cutaway flow diagrams, operating information, sizes, capacities, and dimensions.

Circle letter (BP) on reply card.

(BQ) FIBERGLAS COROMAT

A new 4-page booklet listing the advantages of Fiberglas Coromat as reinforcement for enamel on underground pipe has been pulished by Owens-Corning Fiberglas Corporation. Booklet also lists the Fiberglas Coromat distributors in the various parts of the nation and has an estimating table for determining the quantity of Coromat required per mile for various size pipe.

Circle letter (BQ) on reply card.

(BR) OIL CONDITIONERS

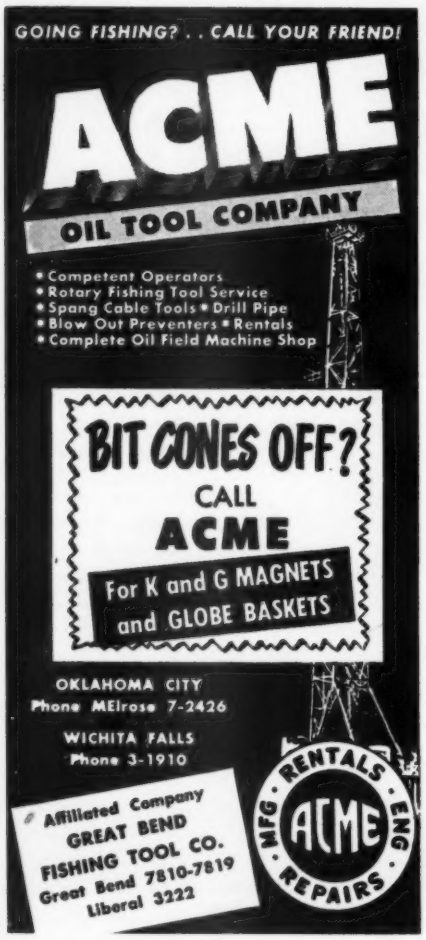
Modern techniques of reclaiming lubricating and transformer oils are the subject of a study just released by the industrial filtration division, U. S. Hoffman Machinery Corporation. This 4-page bulletin, 6th in a series of case studies, is a detailed discussion of the uses of oil conditioners with electric power generating plants and distributing centers. Illustrations show the use of both mobile and stationary oil conditioners in power plants and industrial locations.

Circle letter (BR) on reply card.

(BS) TRENCHER

The new Cleveland Model 240 Trencher for pipe lines and miscellaneous construction projects is described in a 4-page, 2-color bulletin published by The Cleveland Trencher Company. Bulletin contains a table of the 48 available digging wheel and crawler speed combinations providing over 33 digging speeds ranging from .5 ft to 37.3 ft per minute and a table of optional digging widths. Specifications of the Model 240 are on back cover.

Circle letter (BS) on reply card.



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(BT) CRAWLER TRACTORS

The story of the complete line of Allis-Chalmers diesel-powered crawler tractors is pictorially told in "FACTS . . . on a New Breed of Tractors" released by Allis-Chalmers Manufacturing Company. The 16-page, color brochure contains action photographs that give a comprehensive review of the crawlers at work on jobs.

Circle letter (BT) on reply card.

(BU) ENGINE APPLICATIONS

Eight money making features of a variety of diesel engine applications are described in a new booklet titled Cat Diesel Engines Plus Hydraulic Torque Converters published by Caterpillar Tractor Company. This 16-page booklet contains job descriptions and numerous photographs of some of the applications. Included are descriptions of installations in various types of equipment and a complete chart of Cat diesel engines and their horsepower ratings.

Circle letter (BU) on reply card.

(BV) FLANGES

"How Flange Surface Finishes Affect Gasket Sealability and Joint Performance" is the latest in a series of illustrated technical bulletins issued by Johns-Manville. Bulletin discusses the effect of flange surface finishes upon the performance of a gasket. It provides a basis upon which to select the flange surface finish most suitable for a given gasket, and explains why the right finish makes it easy to achieve an initial seal and obtain the best joint performance in service.

Circle letter (BV) on reply card.

(BW) OIL PURIFICATION

Centrico Incorporated has prepared a new 16-page booklet titled "Centrifuges for Oil Processing." Publication gives performance data of Westfalia's three oil separator models for purifying fuel and lube oils and describes Westfalia's new hydraulic lifter and exchangeable bowl liners that cut cleaning downtime 60 per cent.

Circle letter (BW) on reply card.

(BX) PACKING

A folder describing Lattice Braid rod and shaft packings is now available from Garlock Packing Company. Folder points out the construction features of Lattice Braid and describes available materials, sizes, and forms. It also contains illustrative service reports from users in various industries.

Circle letter (BX) on reply card.

(BY) ELECTRIC POWER

Chemical Industry Number of the E-M Synchronizer is a 28-page booklet, recently released by Electric Machinery Manufacturing Company, that deals with the application of electric power apparatus in the chemical industry. The 2-color booklet is illustrated with over 75 photographs, charts, and tables.

Circle letter (BY) on reply card.

(BZ) SPUDDER

A 24-page bulletin (60-L-1) describing Bucyrus-Erie's 60-L spudder is now available. The illustrated booklet offers a complete description of the machine's features along with a general specifications list. The 60-L is designed to handle top-to-bottom drilling to 1500 ft in depth and trailing-in and well-servicing to 2000 ft depths.

Circle letter (BZ) on reply card.

(CA) STEAM GENERATORS

Henry Vogt Machine Company has released bulletin PSG-1 covering Vogt package unit steam generators. Bulletin is well illustrated showing the manufacturing of the different generators and the generators in use.

Circle letter (CA) on reply card.

(CB) COMPRESSOR

Comprehensive engineering details of Cooper-Bessemer's newest engine driven compressor, the GMVA, are presented in a descriptive bulletin released by the company. The 20-page bulletin shows the latest Cooper-Bessemer developments in mechanical scavenging of 2-cycle engines by rotary blower. It contains performance charts and drawings of the engine.

Circle letter (CB) on reply card.

(CC) HYDROCARBONS

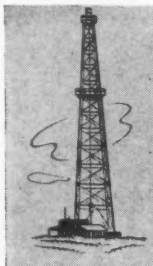
Phillips Petroleum Company has released an attractive 99-page catalog giving specifications, components, typical properties, and product containers of its hydrocarbon products. Remarks on the product and shipping information are also given. A price list is included.

Circle letter (CC) on reply card.

(CD) MAINTENANCE NEWS

The latest issue of Westinghouse Electric Corporation's Maintenance News carries a very excellent how-to-do-it article: How to connect induction motors to the line when the leads are untagged. It also carries a very excellent here's-the-answer-to-your-problem article: Effect of no-load and light-load running on brush life.

Circle letter (CD) on reply card.



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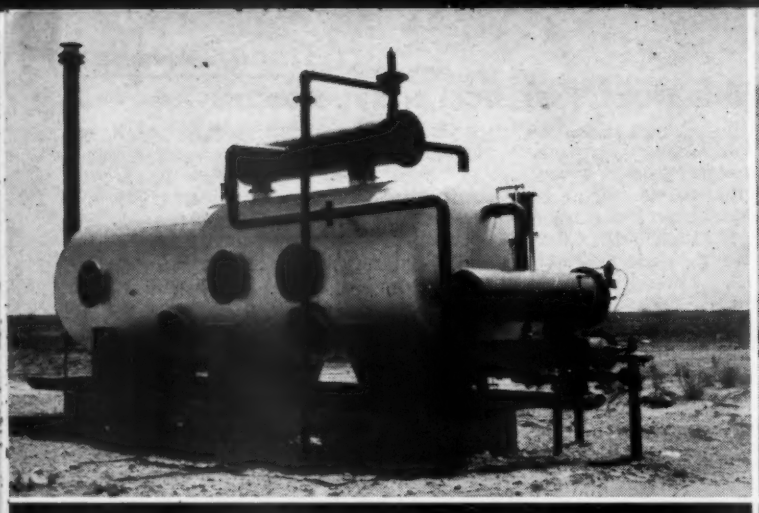
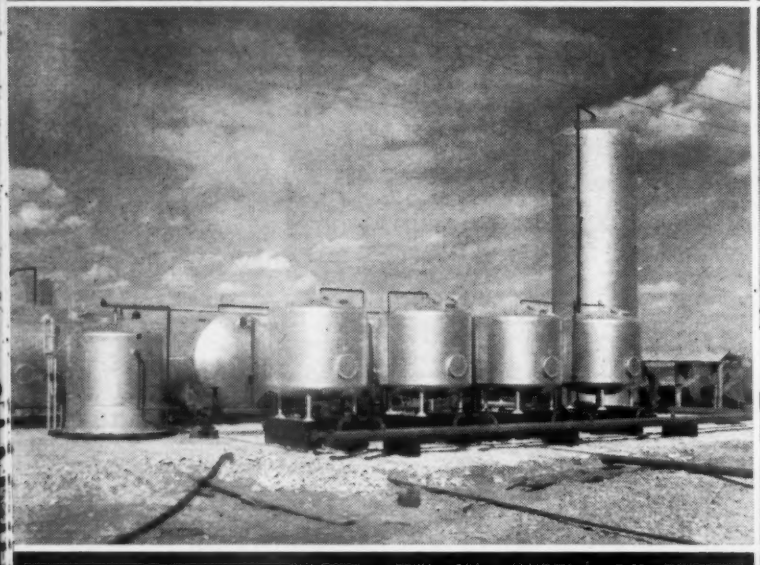
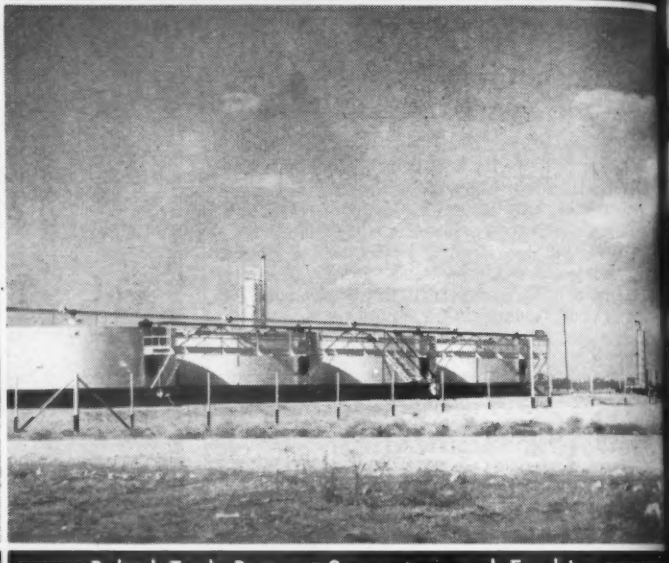


Horizontal Emulsion Treater

Wood Treater and Tank Battery With Steam Generating Indirect Heater



Water Flood Installation



Bolted Tank Battery, Separators and Emulsion Treaters

National

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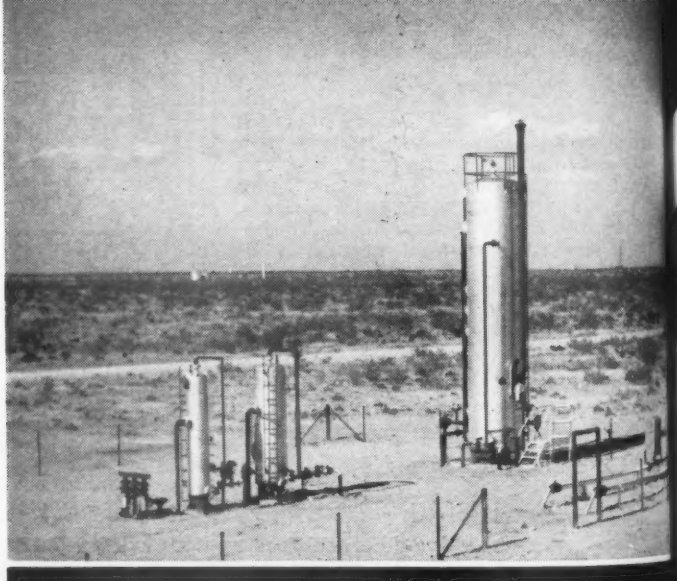

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LETTERS ★

College to Use Article

To Roy M. Willis
The Atlantic Refining Company

Many thanks for sending us a copy of the Atlantic Refining Company's "Manual for Selection of Beam Pumping Equipment." The staff will be able to use this in a number of ways. In particular I will turn it over to Professor C. D. Stahl, who is primarily responsible for our undergraduate course work in producing methods. It may be entirely possible that he will have further questions and, if he does so, he will undoubtedly get in touch with you.

We appreciate also your referring of our inquiry to *The Petroleum Engineer.*

John C. Calhoun, Jr.

Department of Petroleum and
Natural Gas
College of Mineral Industries
Pennsylvania State University

Australian Refinery Active

We have read with interest the article headed "Australian Refining to be Self-Sufficient," by H. Bowden Fletcher, published in your Management Edition for April, 1954. We would like to draw your attention to that part of the survey which deals with the Laverton refinery owned by The Commonwealth Oil Refineries Ltd.

Far from being idle since World War II, the Laverton refinery, which is equipped with an early type of Foster Wheeler distillation unit of 140,000 tons annual rated capacity, was recommissioned late in 1946 and placed on stream in November of that year, with an initial throughput of 141,000 tons, 1,043,000 bbl annually. This rate has been stepped up from time to time and currently the unit is achieving the satisfactory throughput of 163,000 tons, 1,199,000 bbl per annum.

J. H. Rowland

Secretary
The Commonwealth Oil
Refineries Ltd.

Reference Annual in Demand

The 1954 reference annual of *The Petroleum Engineer* is in such a demand in our office that we need two additional copies. Please send them . . . to my attention.

Kenneth S. Swift

Technical Librarian
The Cooper-Bessemer
Corporation
Mount Vernon, Ohio

Appreciates Peret Article

Thanks very much for sending me another copy of J. W. Peret's article, "Comparison of Casing Landing Methods" (The Petroleum Engineer, October, 1953). I am sorry we did not have you run us off about 50 or 100 copies. Thanks very much for helping me out.

H. G. Texter

Chief Field Engineer
Spang-Chalfant
Tulsa, Oklahoma

Interested in Couplings

I have become interested in the "Weld-Ends" couplings described in your article entitled "River Crossing Laid as Emergency Measure" that appeared in your March, 1953, issue. These couplings are manufactured by the Pipe Line Development Company. Would you be good enough to send me the address of the Pipe Line Development Company.

A. William Rhodes

Dow Corning Corporation

Permission Granted

William M. Barret read the article in your August issue (Drilling and Producing Edition) and wants me to read a paper upon the same subject before the Society of Exploration Geophysicists at its Dallas meeting on November 18 and 19.

I presume that it will be O.K. for me to use data from the article "Can Magnetics Find Strat Traps" but I want to ask your permission.

J. D. Haseman

Catalog Number Helpful

In reading your magazine, I have noticed that each of the articles is prefaced with a catalog number. This is very helpful feature and greatly facilitates finding the articles. I only wish the other trade magazines and papers would do the same—but since they don't I wonder if you would be so kind as to send me a break down of this cataloging system.

I subscribe to and file the articles from a number of oil publications and yours is the only one which seems to have a complete and intelligent plan for cataloging these features. I will appreciate any help that you can give me.

James E. Hawkins

Lario Oil and Gas Company
Denver, Colorado